The Glass Industry

Copyright, 1924, by Glass Industry Publishing Company, Inc., New York

Vol. 5 JUNE, 1924 No. 6

Flat Glass

By Arthur E. Fowle*

CHAPTER I

Early History of Flat Glass

Flat glass in some form has existed from the earliest times. Only in the last few centuries, however, has it been manufactured in sufficient quantity and at a cost low enough to make it available for general use.

It is interesting to note that the term "flat glass" until very recent years has been a misnomer. All of this so-called flat glass for use in windows and for similar purposes, with the exception of plate glass, which does not come within the province of our story, was slightly "bowed." It was not until an entirely new process of manufacture was perfected that absolutely flat glass was made available to the world.

Glass bottles, jars and vases, since the time of the earliest records, have been a very important commodity of commerce, and at first thought it might seem that the production of these various shaped glass articles of ancient origin, which are seen in our museums, was more difficult than the production of the common glass window as we know it today; but this is not the case.

The fact is that the quality of the metal itself entering into common window glass must obviously be far superior in clearness and strength to the metal used for ordinary "blown ware." At the same time the mechanical difficulties entering into the production of flat glass are far greater.

Hence it is not to be wondered at that the world was obliged to wait patiently for centuries for the flat glass which today is so indispensable to human living.

Glass was used most extensively by the Romans and its adaption to windows was just beginning when Roman civilization was overwhelmed by the northern barbarians. Glass was largely used by the Romans in pavements and in thin plates as a coating for walls. It was used to some extent in windows, but mica, alabaster and shells were more widely employed.

Such glass as was used for windows was very thick and was available only in small pieces. The ruins of Pompeii revealed that glass half an inch thick was used in the windows of the famous baths. Other traces of Roman glass have been found in Roman ruins at London. Most of the pieces had evidently been made by casting, and the discovery of sheet glass at Silchester shows that this process of making glass was known at that time.

When Justinian built the church of St. Sophia at Constantinople in the fifth century, there were provided great window openings filled with pierced marble screens or frames fitted with small pieces of semi-opaque flat glass, probably produced by casting.

The first mention of the use of glazed windows in Great Britain was in the seventh century when Benedict of Wearmouth sent to France for workmen to glaze a church that he was building.

The use of stained glass in small pieces for leaded windows was characteristic of the Gothic cathedrals in the twelfth and thirteenth centuries. The old masters who mixed the colors for the variety of shades required in this wonderful art of the medieval stained glass windows attained a degree of skill that appears to have died with them, for we are forced to admit that our modern artisans cannot produce the depths of color and variety of shades attained in those times. This is especially true of the deep blues and purples found today in so many of the old world cathedrals and churches.

These instances of the limited use of flat glass in window openings did not mean windows in the modern sense—far from it.

When Edward I brought back his bride from Spain, his father, Henry III, was so delighted with little Eleanor, then in her teens, that he made the youthful couple a present of a house furnished with glazed windows, special mention in the narrative of the day being made of the glazing of the windows.

Pope Pius II, in 1448, expressed surprise in finding at Vienna church windows fitted with flat glass.

In 1467 there were ordered, for the Duke of Burgundy's palace, twenty pieces of wood with which to make frames to be fitted with paper for chamber windows.

In the reign of Elizabeth, the Duke of Northumberland,

*Vice-president and treasurer, The Libbey-Owens Sheet Glass Company, Toledo, Ohio. Copyright, 1924, by The Libbey-Owens Sheet Glass Company. Reprinted by permission.

on leaving his estate, was warned by his steward that he had better order the windows taken out of his house and stored in safe keeping until his return—a significant illustration of the value and importance of a few glass windows even in the grandest habitations of that day. Even the luxury loving Charles II (1660-1685) had no glazed windows in his palace.

At the close of the eighteenth century, shortly after the Revolutionary War, there existed in Paris, the world's most civilized capital, a large corporation engaged in the manufacture of window sashes fitted with oiled paper.

Both France and Belgium reverted to this expedient for enclosing their houses during the first days of reconstruction after the close of the World War—all of the window glass factories being destroyed or unable to resume operations.

The use of flat glass for windows did not become general until the eighteenth century.

An indication of the fact that windows were regarded as a luxury is found in the "window tax" that was levied on these openings by the English government of the seventeenth and eighteenth centuries. A similar tax still is levied in France.

CHAPTER II

Flat Glass in America

Development of flat glass was slow in the New World as well as in the Old, until the modern era of industry arrived. Probably the first attempt to manufacture window glass in the United States was in Allowaystown, New Jersey, in 1738. This venture was unsuccessful as was a later attempt by Robert Hewes, who, in 1790, started a small window glass factory in a forest near Concord, New Hampshire. A few years later, in 1797, Gallatin and Company started a window glass factory in New Geneva, Pennsylvania, ninety miles south of Pittsburgh. This factory proved fairly profitable, the glass at that time selling for $7.00 per box of fifty feet, 10 inches by 10 inches in size.

The use of coal as fuel in glass-making brought a decided change. Previously the industry had been a wandering one moving from place to place as the need for fresh fuel arose. The use of coal made possible steady development at one place.

O'Hara and Craig established at Pittsburgh in 1797 the first window glass plant to use coal.

The first really successful window glass factory in the United States was that of the Boston Crown Glass Company of Boston, Massachusetts. Chartered in 1787, it began operations in 1792, under very favorable conditions, being greatly assisted by the liberal action of the state legislature.

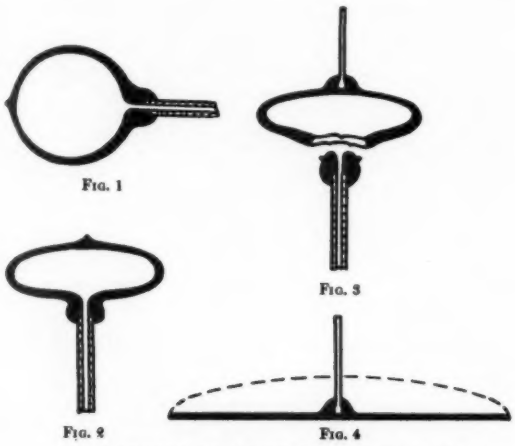
The legislature exempted the company from taxes and their workmen from military duty. It also gave them exclusive rights for fifteen years to manufacture window glass in Massachusetts.

In 1798, records show that this company produced window glass to the value of $82,000. The glass made at this factory was said to be superior to the imported article and was well known among the trade of that time as "Boston crown window glass." Specimens of this old crown glass can be seen today in many of the old Colonial houses in New England.

The use of glass for windows was by this time becoming widespread. The American pioneers who pushed their way across the western frontiers each carried a small four-paned window, which the homestead law of the time required to be built into every cabin.

This general use of glass was made possible by better methods of manufacture. The casting process for making flat glass never attained commercial possibilities. The first real window glass was made by the blowing process and was known as "crown glass."

This process consisted in gathering a large globule of molten glass on the end of a blowpipe, the glass then being



FOUR STAGES OF MAKING "CROWN" GLASS

blown into hollow spherical shapes (Figs. 1 and 2, page 100). Next a punty or iron rod, tipped with molten glass, was applied to the opposite side of the sphere and the blowpipe was detached, thus leaving a hole (Fig. 3).

The globe attached to the punty was then reheated and the punty given a whirling motion that caused the glass to flash outwardly into the form of a disc, adhering to the punty by the boss in the center (Fig. 4). The disc was removed from the punty, annealed in an oven and then cut into small sheets. The centers of the discs containing the bosses or "bull's-eyes" were used for decorative effects and were employed largely in the sidelights and transom lights of the Colonial doorways of New England.

This method of making flat glass was obviously very expensive and wasteful and furthermore did not make possible the production of anything but very small lights.

CHAPTER III

The Hand Process

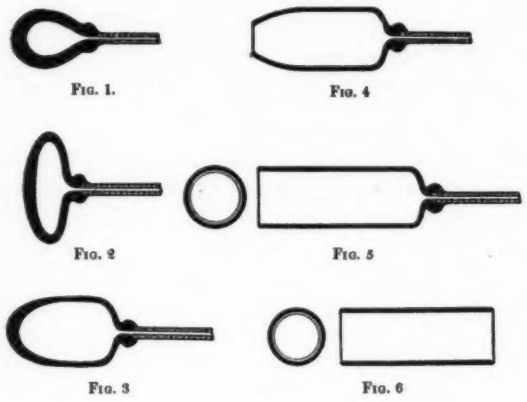
Sheets of flat glass made by the process described in the previous chapter were necessarily limited in size and very expensive. This furnished a great incentive to the study of modifications and development of the method so that larger sizes could be produced and at less cost.

The so-called "hand process" of blowing glass in a cylinder form and its subsequent flattening, as we know it today, is a slight advance over the old crown glass method. It is uncertain when this hand process was first started.

Mention is made of its being used as far back as the eleventh century, but it did not come into general use until early in the nineteenth century. This hand process continued to be the accepted method for making window glass until about 1903.

A brief description of this process is of interest in order to indicate the great skill and arduous labor necessary to produce the so-called flat glass by this method.

The blower, gatherer and snapper constitute what is known as a "shop" in this trade. The gatherer, using a heavy blowpipe about five feet long, gathers a small ball of molten



SIX STAGES OF "HAND CYLINDER PROCESS"

glass on the end, removes it from the furnace, blows it slightly and then gathers more glass (Fig. 1, page 100). This operation is repeated four or five times until he gathers sufficient glass to produce a cylinder of the desired size. The ball thus gathered weighs from twenty to forty pounds, according to the size of the cylinder to be produced.

The gatherer carries the blowpipe with the adhering mass of semiplastic glass to the "blower's block," an iron mold set in water and lined with charcoal to prevent the surface of the ball from becoming marred by direct contact with the iron. The gatherer then blows into the pipe while giving the ball and pipe a rotary motion on the block, at the same time pulling it upwards in an inclined direction (Figs. 2 and 3). By this means the ball assumes a pear shape and thus forms what is known as the "neck" of the cylinder in which condition the pipe with the pear-shaped mass of glass is passed to the "blower" who reheats the mass at the blow furnace and then swings the pipe over the "swing hole," or alley, alongside of the furnace.

By highly skillful heating, blowing, reheating and dexterous manipulations, the cylinder is elongated, the sides being kept as nearly as possible to the desired thickness necessary to produce either single, double or heavier sheets.

These intermittent operations are carried on until the bottom of the cylinder is of the same thickness as are the sides. This closed end is then exposed to the heat of the blow furnace while the workman at the same time blows into the pipe and then by placing his thumb over the end confines the air under slight pressure. The air, being expanded by the heat from the furnace, finally bursts out through the bottom (Fig. 4). The cylinder with its ragged, open end, thus produced, is again swung out into the "swing hole" in such a manner as to make it completely cylindrical to the end (Fig. 5).

The blowpipe with the completed cylinder still attached by the neck is next passed to the "snapper" who removes the pipe by touching a cold iron to the glass close to the point of the pear-shaped neck or cap. The cap is then cut off by applying a thread of hot molten glass around the cylinder at the shoulder and again applying a cold iron (Fig. 6). The completed cylinder, thus produced, is split open longitudinally by passing a hot iron back and forth along the inside and subsequently applying a cold iron. Cylinders thus formed vary in size from twelve inches in diameter by fifty inches in length to twenty inches in diameter and seventy inches in length.

The cracked open cylinder in this form is then ready for the "flattening process"—another very difficult and highly skilled step in the production of sheet glass by this method. The cylinder is laid on a light iron carriage and carefully introduced into the heated interior of the flattening oven and when sufficiently heated it is lifted from the carriage by long iron tools and placed on the flattening stone, a large fire clay slab with a well-polished surface. The split cylinder gradually softens and by means of other tools is spread out upon the stone and then ironed or flattened by rubbing with a block of wood mounted on a long iron handle.

The "flattening table" containing the stone is revolved and the stone then moved into a cooler chamber, another stone being moved into the hot flattening oven ready to receive another cylinder and the process repeated. The flattened sheet is now picked up by a long-handled fork and placed in the hot end of the annealing oven or lehr, through which it gradually passes, during the annealing process, towards the cool end. The sheets are then removed and dipped for a few seconds in a hot bath of diluted hydrochloric acid. This dipping process arrests any further action of the alkali that is used in the original glass batch and prevents the glass fading through the action of the elements.

A little reflection upon the physical characteristics of the split cylinder in passing from its cylindrical form to the flat sheet is interesting. It can readily be seen that in the flattening process previously described, the attempt is made to force the inside circumference to equal that of the outside. This is manifestly impossible since the glass cylinder is heated only to the bending point.

The result of this fact alone is that this ironing out or flattening process cannot produce an absolutely flat sheet of glass and the finished sheet will have an appearance similar to hammered brass or else it will be full of long, irregular waves. Both conditions produce unpleasant effects of distortion when objects are seen through glass made in this way.

Other defects quite prevalent in cylinder glass, which of necessity requires the flattening process, are the "burns" or marks caused by the sheet of glass coming in contact with an excessively hot or dirty flattening stone. In addition to the foregoing and as a further result of attempting to

make the outside and inside circumference of the cylinder equal in the flattened sheet, the sheets are always noticeably bowed or bent.

On this account the sheets of glass always have to be laid the same way in the packing boxes in order to minimize the inevitable breakage in shipment. Furthermore, in subsequent glazing, the glass made by this method, either by hand or by the more advanced cylinder machine process, must be placed in the sash with the bowed side out.

The hand cylinder process of making sheet glass has been the accepted method for many years and even in our present day of progress is still used extensively in many countries of Europe, while in the United States approximately one-third of our window glass is produced by this method which, however, is fast becoming obsolete on account of the recent developments in the art.

It is evident that while the hand cylinder process is an advance in a commercial way over the old crown process, the method is still very expensive and obviously laborious and hard upon the workmen.

The artisans employed in the manufacture of sheet glass by this process have for years jealously guarded their trade, allowing only a limited number of apprentices. They have rigorous rules and regulations in respect to the teaching of these apprentices to follow in the footsteps of the older men, who are forced to abandon their trade prematurely because of its rigorous demands. Here again is seen ample reason for study and experiment in order to find a way of reducing this tremendous amount of arduous labor and so work was begun in the early Nineties on a mechanical method for eliminating the human gatherers, blowers, and snappers.

CHAPTER IV

Machine Cylinder Developments

About 1896 J. H. Lubbers, a window glass flattener by trade, began experimenting on a machine wherein the air was mechanically introduced into the blowpipe while the pipe was raised on guides during the formation of the cylinder. The process looked very simple but it took years of effort and several million dollars to bring this machine cylinder process to the point where it is today.

While this method is a step in advance of the hand process, as it eliminates the arduous work of the gatherer, the blower and the snapper, makes better and cheaper glass and produces larger sheets, the product is still "cylinder glass" and the cylinders must pass through the same troublesome flattening process that produces the same defects as in glass made by the hand process.

CHAPTER V

The Colburn Developments

It is therefore quite obvious that the logical method of making sheet glass is to make it in flat form at the outset. One naturally asks: "Why make it round and then change its form to a flat sheet?" Books could be written on the study and experimentation of drawing glass in sheet form. There is on file a British patent taken out by a man named Clark, February 19, 1857, and a very similar Belgian patent taken out by a man named Loup, March 12, 1857. These were followed by an extraordinarily large number of patents on sheet glass from that time to the present and it can be well said that there is hardly another industry today in which such a wealth of study, effort and money has been expended; and finally there was accomplished what the majority of practical glass men were ever claiming as the impossible—the Colburn sheet glass machine as perfected today by The Libbey-Owens Sheet Glass Company.

The inventor of the process, Irving W. Colburn, became interested in glass in 1898 and started a small experimental plant at Blackford, near Philadelphia, Pennsylvania, where he worked on a machine for blowing lamp chimneys and tumblers. After working two years and expending $17,000, he abandoned this work and moved to a small plant at Franklin, Pennsylvania, where he interested some of his friends in assisting him to carry on his experiments from 1901 to 1905, on an idea he had for a machine to blow cylinder glass. His ideas proved to be merely fantastic dreams and while he did succeed in mechanically producing a few cylinders, they were of poor quality and the cost of operation was prohibitive. During these six years he continually had in mind the idea of producing glass in sheet form by mechanical means without the necessity of first making it in the cylindrical form.

We find now that this idea has been in the minds of many glass men, both here and in other countries, for the past half century as evidenced by the array of paper patents on sheet glass from the patents of Clark and Loup in 1857 up to the present day. It remained, however, for Colburn to give to the world the first workable machine producing commercial flat-drawn sheet glass. His first idea embodied in the present machine occurred to him in 1905 when he witnessed a paper-making machine in operation.

Colburn was a man who invariably had ideas in advance of his fellows and had the faculty of surrounding himself with close friends who always seemed willing to give a ready ear to his ideas as well as to assist him in a financial way. He discussed with many of these friends his ideas of making sheet glass, after having seen the paper machine in operation, and succeeded in securing additional financial backing; and in August, 1906, formed the Colburn Machine Glass Company. During the following two years he built many machines, crude at first, but gradually approaching a solution of the difficult problems with which he found himself confronted. With him, as with many inventors, success was always just ahead, leading him on like the will-o'-the-wisp. He, however, had the inventor's temperament: always hopeful, always confident of ultimate success, and endowed with a wonderful determination to accomplish his end.

Strange as it appears today, the process was thought to be a success in 1908 and the Colburn Machine Glass Company granted a license for the use of one machine to a company at Reynoldsville, Pennsylvania. The newspapers of the day carried glowing accounts of the possibilities of the Colburn machine. The new plant started off under apparently very favorable conditions but it was soon proved that the end of the journey was a long way ahead.

The trials and tribulations of Colburn and his friends during the following four years form a pathetic story.

Machine after machine, furnace after furnace, was built,

torn down and rebuilt, until in all, from 1905 to 1912, fifteen different machines had been constructed and more than $1,000,000 expended with only a few thousand boxes of poor quality glass to show for the tremendous outlay of human effort as well as money.

In 1911 the credit of the Colburn Machine Glass Company was gone; the company was declared bankrupt and its assets, including the numerous domestic and foreign patents of Colburn, were put up at public auction on February 8, 1912, at Pittsburgh.

CHAPTER VI

The Libbey-Owens Company

After years of effort and the expenditure of a large amount of money, Colburn's friends finally lost confidence in his process, though they still retained their faith in him.

Practically all of the many window glass manufacturers who had followed his experiments up to the day the patents were put up at public auction regarded the patents as of no value. There was one man, however, who had the vision and clear insight to see just what was needed in the process to make it an undoubted success. That man was Michael J. Owens, the master inventive mind in the American glass industry for the last twenty-five years.

Through his efforts and earnest, persistent recommendations to Edward D. Libbey, his associate for many years, he induced The Toledo Glass Company, of which Mr. Libbey was president, to purchase the Colburn patents from the trustee in bankruptcy. The purchase of these patents by The Toledo Glass Company in 1912 marks an epoch in the history of the window glass industry of the United States as well as throughout all countries of the world where window glass is manufactured.

The Toledo Glass Company immediately began the erection of a very complete experimental, one-machine plant at Toledo, Ohio, beginning operations in November, 1913. They soon found that there was much to be done and still much to learn in order to perfect the process.

As close as The Toledo Glass Company was to success during 1915, the late Mr. James Chambers, who might well be called the father of the American window glass industry, was practically the only manufacturer who had faith in the ultimate success of the process. Practically all others who were privileged to witness the two years' experiments at Toledo were not backward in stating that Mr. Libbey, Mr. Owens and their associates were foolish in spending such sums of money on the much-maligned Colburn machine. Mr. Libbey, however, with his usual foresight, as evidenced in directing other projects of a similar nature, brought to bear on the problem his splendid courage, faith and perseverance, and as a result success was finally attained.

The connection of The Toledo Glass Company with the Colburn sheet glass machine was very similar to its earlier connection with the Owens Bottle Machine, which it developed under similar circumstances and later sold to The Owens Bottle Company. In the early spring of 1916, after having spent well over $1,000,000, it was quite evident to those in charge of the experiments that success would soon be assured.

This happy conclusion was reached in May, 1916, when The Libbey-Owens Sheet Glass Company was formed and bought from The Toledo Glass Company all of its patent rights, both domestic and foreign, covering the sheet glass machine. One condition of this sale was the reward received by Colburn for his years of effort in the development of the machine. The Toledo Glass Company assigned to him a very liberal stock interest in the new company, which enabled him to discharge the many obligations assumed during the earlier years of his work, as well as to provide liberally for his family.

The Libbey-Owens Sheet Glass Company immediately began the erection of a six-unit plant at Charleston, West Virginia, at an expense of $1,500,000, and commenced drawing glass in October, 1917. By a strange irony of fate Mr. Colburn's life was cut short at this time just at the fruition of his many years of effort.

The success of the company was assured from the start, and the demand for its superior product so increased that in 1920 the plant was doubled in size and further enlarged in 1923, making it the largest as well as the best equipped window glass plant in the world today, representing an investment of more than $7,000,000. The plant is equipped with eighteen Colburn machines and has a capacity of 3,000,000 fifty-foot boxes of window glass a year.

CHAPTER VII

The Libbey-Owens Process

With the history of flat glass thus outlined in the previous chapters, it should be of interest now to consider in detail the Libbey-Owens process for making flat-drawn sheet glass.

The preliminary operations are very similar to those in other forms of glass manufacture. The mixture of the ingredients, called the batch, composed of sand, ground limestone, soda ash and salt cake, with a certain amount of cullet or broken glass, is fed into the furnace and melted under a heat of about 2,500 degrees Fahrenheit. The furnace contains from 600 to 900 tons of molten glass. This molten glass passes from the melting chamber to the refining chamber, where it is gradually settled or refined preparatory to entering the shallow drawing pot from which the sheet is drawn.

This pot or pan is suitably placed in a pot chamber and supported upon silica brick stools. By means of heat applied underneath and around the edges of the pot, the temperature of the glass is carefully maintained at the proper degree of heat for the ultimate formation of the sheet.

To start the drawing of the sheet, the machine is placed in reverse motion, which allows a bait to be introduced into the drawing pot containing the molten glass. The bait is a simple affair consisting of a flat iron bar three inches wide and about six feet long, attached to strips of flexible metal that allow the bait to pass over the bending roll, down into the glass. The molten glass immediately adheres to this bar. Then the machine is placed in forward motion, thus pulling the bait with its adhering mass of plastic glass over the bending roll onto the horizontal flattening table and thence into the lehr. When the bait reaches the end of the flattening table, about ten feet from the bending roll, it is cracked off and removed and the sheet of glass is allowed to continue on its way through the 200-foot annealing lehr.

The natural question that arises when describing the formation of the sheet of glass in the Colburn machine is: "Why doesn't the sheet pull to a point? What is it that sustains it at a constant width?"

The answer is that the sheet is kept at an even width by passing the outer edges of the sheet between two sets of water-cooled, knurled rolls, placed an inch or two above the surface of the molten glass, just inside the edges of the drawing pot. These knurled rolls engage the sheet for about two inches on each side and serve to sustain it at a constant predetermined width. These edges are thicker than the intervening sheet of glass. The real pulling of the sheet is accomplished by engaging the outer edges of the sheet—after it passes over the bending roll—between the flattening table and a series of grip bars running in the same direction and placed just above the flattening table.

The lehr is provided with two hundred power driven rolls, covered with asbestos composition, over which the glass passes in continuous sheet form, emerging at the end onto a movable cutting table. Here it is cut into sheets of suitable size, dipped in a hot solution of hydrochloric acid and then distributed to the several cutting stalls. Experienced cutters then carefully select sheets, grade them and cut them into commercial sizes. These are packed with straw in boxes each containing fifty square feet of glass, regardless of the size of the sheets.

Sheet glass made by this process is absolutely flat, of uniform thickness, and is free from the distortions so common and annoying in all glass made by either the hand process or the cylinder machine process. It thus reaches the user with a natural fire finish, and without the defects inherent in glass made by the flattening or ironing out methods, employed by all other processes.

The machine will make glass from 1/24 of an inch to 5/16 of an inch thick, the thickness being governed by the temperature of the glass in the drawing pot and the speed of the machine which varies from twenty-five to one hundred inches a minute, according to the thickness of the sheet being pulled. The capacity of one machine is six hundred fifty-foot boxes of single strength glass in twenty-four hours.

It can readily be seen that the Libbey-Owens process of making sheet glass is practically automatic and eliminates the greater part of the strenuous, exhausting and nerve-racking labor so common in the manufacture of most articles of glass. It has therefore proved a boon to the artisans who produce the *flat glass* that plays such an important part in the life of every community.

CHAPTER VIII

Flat Glass and Progress

What human value has this very modern art of the drawing of flat glass and the accompanying art of window glazing? It is not only that the common use of glazed windows makes homes brighter, more cheerful, more livable in a hundred ways, letting in the sunshine with its purifying properties and its warming, vitalizing influence on body and soul. That is of inestimable value—a value not to be sensed even remotely, except by contrasting the cottage of today with the gloomy, disease-infected hovels of the common people of only three centuries ago. The value of window glazing is even more important than that.

Compare the few small panes set in marble in the greatest of ancient churches with the tremendous fenestration of our modern steel frame factories where production can be carried on by daylight, in climate under human control, no matter what the outside weather may be. Window glass has not only improved the living conditions of man but has contributed tremendously to the development of modern industry.

Professor R. E. Danforth, of Rutgers College, has said in the *Scientific Monthly*: "The great change in home life and the change in industrial life, and in the industries themselves could not begin until an abundance of cheap glass filled all homes with a flood of daylight, and all shops and offices and factories as well, keeping in the artificial heat at the same time. A host of new industries sprang into being in the wake of window glass, and these begat other industries, scientific inventions and discoveries, with magic rapidity. The general use of window glass is a thing of yesterday, and in its train there now follows a striking pageant of industrial revolutions, large factories were made possible, big business began, and the physical conditions of home life were completely changed.

"With window glass, industry in shop or office could go on without a break caused by the weather, and, what is of still greater consequence, without the long winter hiatus, during which bright thoughts could be forgotten and the best of intentions fade away."

So window glass has brought control of the weather, and controlled weather means continuity of effort in labor and invention, which means production on the modern scale. Nor is this control confined to buildings. Portholes of ships, windows of railway cars, the glazed bodies of automobiles, all furnish shelter, warmth, and light to keep men well and comfortable while going about the business of the world.

Composition of Horak Glass*

Venzel Horak of Czechoslovakia has obtained a patent on a glass which has great elasticity and which in case of breakage is not shattered in a large number of fragments. It does not easily show devitrification. Its composition is as follows:

	Per cent
Sand	60-70
Boric acid	15-30
Potassium carbonate	1-2
Sodium carbonate	3-6
Mica	0-4
Zirconium	1-3
Titanic acid	1-3

The molecular formula is approximately

$$70SiO_2,\ 20B_2O_3,\ 3RO\tfrac{1}{2}Al_2O_32ZrO_2$$

(Represents either sodium or potassium)

The glass is a good conductor of heat and resists sudden changes in temperature.

*Translated from the "*Revue Gênerâle des Colloides*," February, 1924.

A Japanese patent No. 41,723 was granted to Takaji Egusa, February 13, 1922, for plating glass with magnesium. The magnesium is vaporized in a vacuum by electric heat and deposited on the surface of the glass, which is given a silver white finish. A small amount of red phosphorus hastens the chemical action. A golden color may be obtained by using a larger amount of red phosphorus.

Design of a 14-Pot Recuperative Glass Furnace

By E. W. Koering*

The object of this article is to present a common method of designing a recuperative glass furnace. The necessary data were gathered together from various sources and due acknowledgment is given in the list of references at the end of the article.

The designed capacity of this furnace is 6,350 kilograms or 7 tons per day and since factory practice shows that about 1 kilogram of coal is required for each kilogram of glass melted it is assumed that 6,350 kilograms of coal will be burned in 24 hours. The furnace is to be operated on producer gas.

$$\frac{6{,}350}{24 \times 60 \times 60} = 0.0737 \text{ kilograms of coal per second.}$$

Analysis of producer gas		Analysis of Pennsylvania Coal	
CO_2	8.7	Carbon	80.0
O	0.0	Hydrogen	4.6
C_2H_4	0.0	Nitrogen	0.0
CO	20.70	Oxygen	6.7
CH_4	2.50	Sulphur	0.7
H_2	12.50	Moisture	2.0
N_2	55.60	Ash	6.0
		Heating value, 8,000 calories.	

Carbon in the coal, $.8 \times 6{,}350 = 5{,}080$ kilograms.
Carbon in the ash, $.4 \times 928 = 371.2$ kilograms.

Carbon used = 4,708.8 kilograms.

$$\text{Carbon lost in the ash} = \frac{371.2 \times 100}{5{,}080} = 7.3 \text{ per cent.}$$

Dry gas per kilogram of coal = 3.74 cubic meters.
Coal used per second = 0.0737 kilograms.
$0.0737 \times 3.74 = 0.278$ cubic meters gas per second, or $0.278 \times 1.025 = 0.285$ cubic meters wet gas per second at N.T.P. (Normal temperature and pressure.)

The temperature of the gas at the producer is taken as 640° C.

$$\text{Volume at } 640^\circ \text{ C.} = 0.285 \frac{640 + 273}{273} = 0.953 \text{ cubic meters.}$$

The size of the gas flue is found as follows:

$q = Av$, where q = quantity, A = area, and v = maximum allowed velocity = 3 meters per second.

$$A = q/v = \frac{.953}{3} = 0.318 \text{ sq. m., or } 3.42 \text{ sq. ft.}$$

Since the gas flue is usually circular in cross section the inside diameter will be $d = \sqrt{\frac{4 \times .318}{\pi}} = .635$ m., or 2.09 ft.

The gas is conducted directly to the furnace without being regenerated.

*Civil Engineer, Vineland, N. J.

The quantity of air needed is determined as follows:

Gas analysis		Air required	
H_2	12.50	$12.5 \times 2.38 =$	29.8
CO	20.70	$20.7 \times 2.38 =$	49.3
CH_4	2.50	$2.5 \times 9.54 =$	23.9
CO_2	8.70		
N_2	55.60		
	100 vols.		103 vols.

To insure complete combustion of the gas allow about 30 per cent excess air.

$1.30 \times 103 = 134$ vols. of air per 100 vols. of gas at N.T.P.

$$\text{Total air required} = \frac{.278 \times 134}{100} = .372 \text{ cu. m. per sec. at N.T.P.}$$

The temperature of the air at the intake is assumed to be 30° C.

$$\text{Volume of air at intake} = .372 \times \frac{30 + 273}{273} = .414 \text{ cu. m. per second.}$$

The products of combustion are as follows:

		CO_2	N_2	H_2O	O_2
H_2	12.5	....	23.5	12.5	..
CO	20.7	20.7	39.0	...	..
CH_4	2.5	2.5	18.8	5.0	..
CO_2	8.7	8.7	....	....	..
N_2	55.6	....	55.6	....	..
30% excess air		....	26.8	....	7.2
		31.9	163.7	17.5	7.2

This gives a total of 220.3 volumes.

The percentage composition of the outgoing gases is as follows:

$$CO_2 \quad \frac{31.9}{220.3} \times 100 = 14.50 \text{ per cent}$$

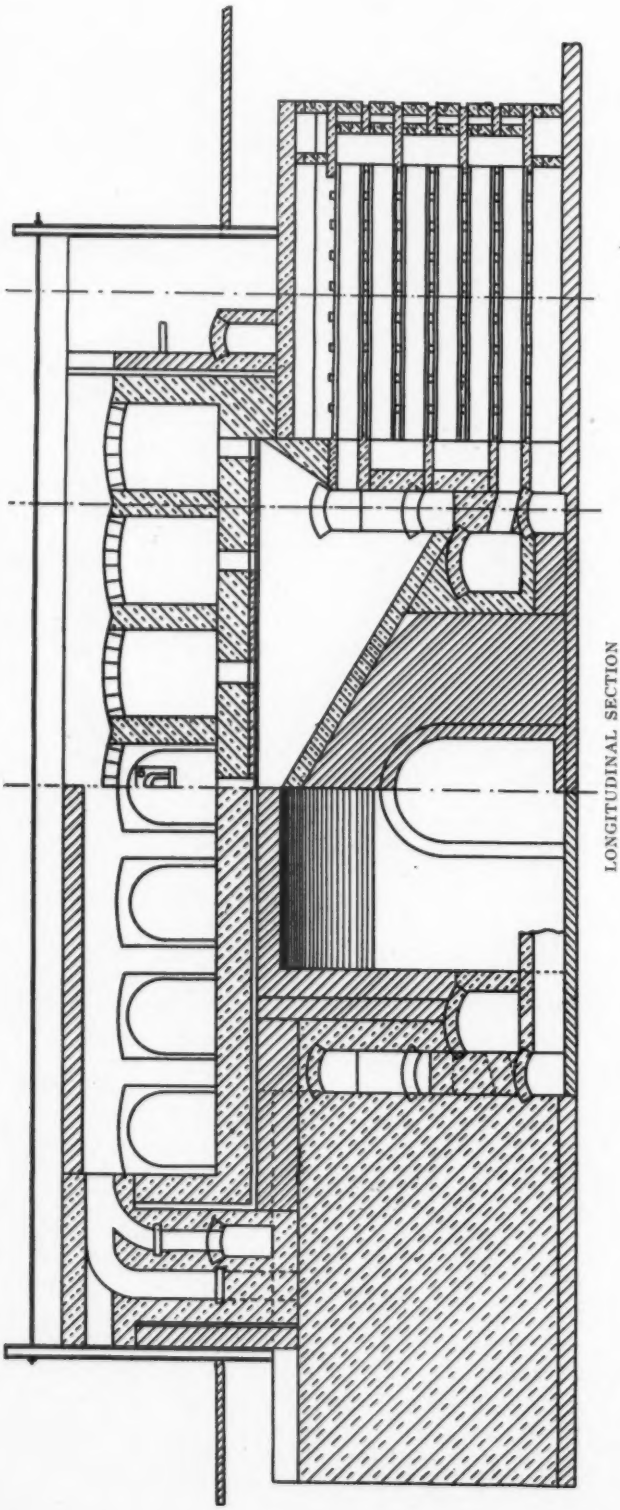
$$N_2 \quad \frac{163.7}{220.3} \times 100 = 74.30 \text{ per cent}$$

$$H_2O \quad \frac{17.5}{220.3} \times 100 = 8.00 \text{ per cent}$$

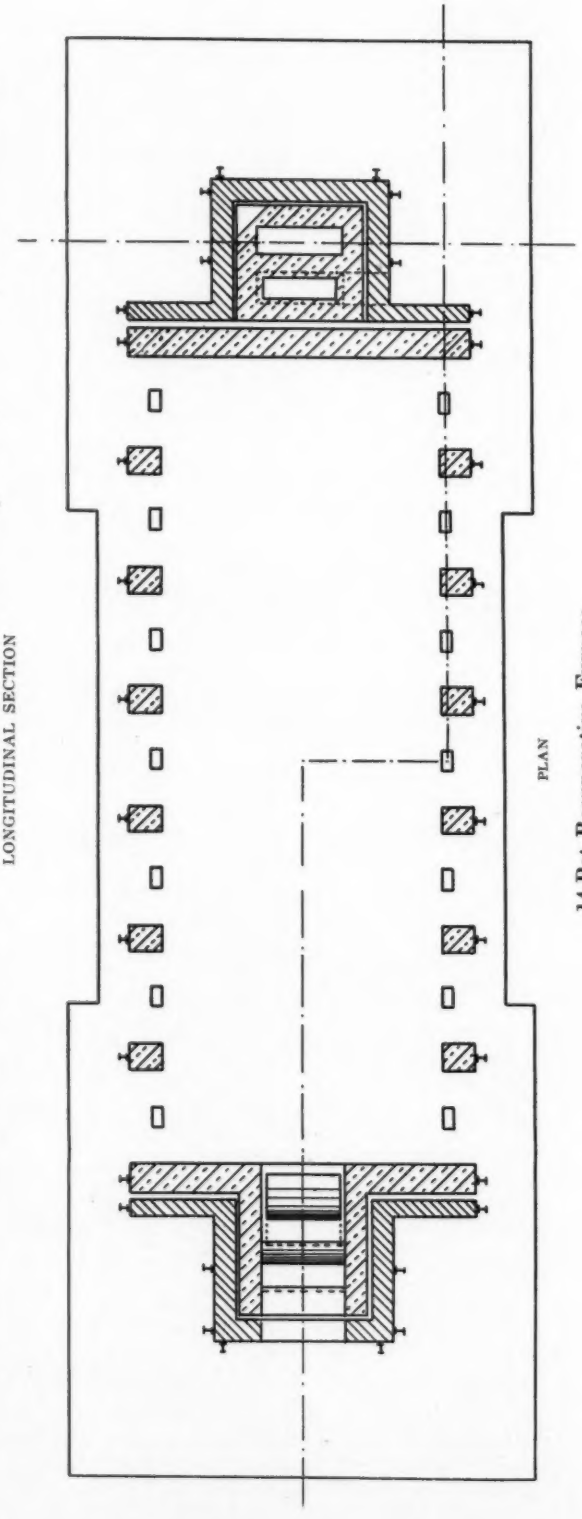
$$O_2 \quad \frac{7.2}{220.3} \times 100 = 3.20 \text{ per cent}$$

100 vols. of producer gas gives 220.3 vols. of waste gases at N.T.P. 0.278 vols. give $220.3 \times 0.278 = 0.612$ vols. of waste gases at N.T.P. from which heat may be extracted in the recuperator.

The thermal capacities of gases from absolute zero (—273° C) to a temperature $T = 273 + t°$ may be expressed by a parabolic formula between two parameters, $Q = a \frac{T}{100} + b \frac{T^2}{1000^2}$ in which (a) is a constant for all gases and (b) is another constant but variable for different gases.



LONGITUDINAL SECTION



PLAN

14-Pot Recuperative Furnace

The proportionate amounts of the different gases in the products of combustion given off in one second are:

$$CO_2 \quad \frac{14.50}{100} \times 0.612 = 0.089 \text{ cu. m.}$$

$$N_2 \quad \frac{74.3}{100} \times 0.612 = 0.454 \text{ cu. m.}$$

$$H_2O \quad \frac{8.0}{100} \times 0.612 = 0.049 \text{ cu. m.}$$

$$O_2 \quad \frac{3.2}{100} \times 0.612 = 0.020 \text{ cu. m.}$$

Total 0.612 cu. m.

The weights of the above at N.T.P. are:

CO_2 $0.089 \times 1.065 = 0.175$ kg.
N_2 $0.454 \times 1.254 = 0.570$ kg.
H_2O $0.049 \times 0.804 = 0.040$ kg.
O_2 $0.020 \times 1.439 = 0.029$ kg.

The waste products enter the recuperator at 1400°C and it is assumed that the temperature drops to 400°C at the recuperator exit. The average temperature is then, $\frac{1400 + 400}{2} = 900°C.$

The total heat capacities of the products of combustion at 1400°C and 400°C are found as follows, from curves in Damour's "Les Chauffages Industrielles."

		Wt. kg.	Heat Cap.	Calories.
Temperature 1400°C	CO_2	0.175 ×	435 =	76.2
	N_2	0.570 ×	400 =	228.0
	H_2O	0.040 ×	943 =	37.7
	O_2	0.029 ×	334 =	9.3
			Total	351.2
Temperature 400°C	CO_2	0.175 ×	91 =	15.9
	N_2	0.570 ×	100 =	57.0
	H_2O	0.040 ×	203 =	8.1
	O_2	0.029 ×	88 =	2.6
			Total	83.6

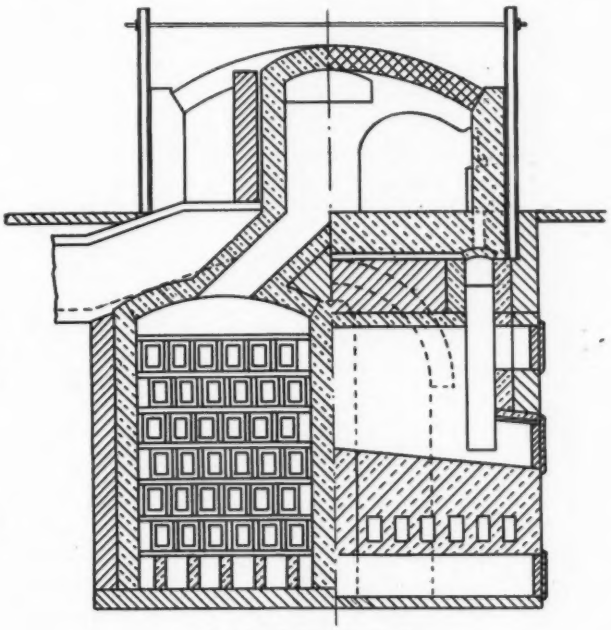
Total available calories per second, 351.2 — 83.6 = 267.6.

The air required for combustion enters the recuperators at 30°C and it is assumed will leave the recuperators at 1000°C. Volume of dry air used = 0.372 cu. m. per second. Weight of dry air used = 1.294 × 0.372 = 0.482 kg. per second.

This air contains $0.77 \times 0.482 = 0.372$ kg. N_2 and $0.23 \times 0.482 = 0.110$ kg. O_2.

		Wt. kg.	Heat Cap.	Calories.
Temperature 1000°C	N_2	0.372 ×	260 =	96.8
	O_2	0.110 ×	230 =	25.3
			Total	122.1
Temperature 30°C	N_2	0.372 ×	7.50 =	0.7
	O_2	0.110 ×	6.55 =	2.8
			Total	3.5

122.1 — 3.5 = 118.6 calories per second to be recovered from the waste gases. $\frac{118.6}{267.6} \times 100 = 44.4$ per cent, the portion of the total available calories in the waste products utilized, leaving 55.6 per cent for losses through radiation.



TRANSVERSE SECTION

The next step is to design the recuperator. Various types and shapes of recuperator flue tile are on the market and each type lays claim to certain qualities such as, low cost, simplicity of construction, non-leaking joints, long life, ease of cleaning, ease of repair or replacement, high efficiency, etc. For the sake of simplicity, a flue of circular cross section is assumed in this design and the required length and area computed. Knowing the length and area of flue required any standard type of equivalent length and area may be substituted in actual construction. This theoretical flue will, for convenience, be called the equivalent tube.

The number of calories that can be transmitted through the equivalent tube in one hour may be computed as follows:

$Q = kFT$ where,
k = Coefficient of transmission.
F = Inside area of tube of unit length.
$T = t_1 - t_2$
t_1 = Mean inside temp. 900°C.
t_2 = Mean outside temp. 515°C.
Find k by the following formula:

$$\frac{1}{k} = \frac{1}{a_1} \cdot \frac{d}{D} + \frac{1}{a_2} + \frac{d}{2\lambda} \log_e \frac{D}{d}$$

a_1 = Coefficient of heat transmission for outer surface.

a_2 = Coefficient of heat transmission for inner surface.
D = Outer diameter of tube.
d = Inner diameter of tube.
λ = Coefficient of conductivity for fire brick = 0.7.
a_1 = 8.

$$a_2 = 125\ S\ \frac{1.0077^{t_1} - 1.0077^{t_2}}{t_1 - t_2} + 0.55b\ (t_1 - t_2)^{0.233}$$

S = Radiation coefficient for fire brick = 3.60.
b = Correction coefficient for air = 4 for compressed air and 5 to 6 for free moving air.

$$a_2 = 125 \times 3.6\ \frac{1.0077^{(900)} - 1.0077^{(515)}}{385} 0.55 \times 6 \times 385^{(.233)} = 113.2$$

Assume a rectangular section of flue, say, 18 × 28 cm. or about 7 × 11 inches. Then the equivalent diameter of a round pipe is:

$$d = \frac{92}{\pi} = 29.4 \text{ cm. or } 0.294 \text{ m.}$$

$$D = 0.294 + 2 \times .05 = 0.394 \text{ m.}$$

$$\frac{1}{k} = \frac{1}{8} \times \frac{.294}{.394} + \frac{1}{113.2} + \frac{.294}{1.4} \log_e \frac{.394}{.294} = 0.190$$

$$k = \frac{1}{0.190} = 5.26.$$

$$Q = kFT = 5.26 \times \pi d \times 1 \times 385 = 1870 \text{ calories.}$$

$$\text{Length of flue required} = \frac{118.6 \times 60 \times 60}{1870} = 228 \text{ meters.}$$

Allow about 50 per cent for spreaders, end connections, etc.

$$228 \times \frac{150}{100} = 340 \text{ meters, gross length of flue required.}$$

This length may be divided among any suitable number of recuperators or flue chambers. In this design there are four chambers.

$$\text{Flue per chamber} = \frac{340}{4} = 85 \text{ meters.}$$

Allow a mean velocity of 2¼ meters per second for the waste gases through the recuperator.

$$\text{Volume of waste gases at } 900°\text{C} = 0.612 \times \frac{1173}{273} = 2.63$$

cu. m. per second.

$$\text{Flue area required} = \frac{2.63}{2.25} = 1.17 \text{ sq. m.}$$

Area of one tile 18 × 28 cm. = 504 sq. cm. or 0.0504 sq. m.

$$\frac{1.17}{.050} = 23.4, \text{ say 24 tile, and since there are four chambers there will be } \frac{24}{4} = 6 \text{ tile in each tier to give the necessary flue area.}$$

Size of the air flue.—Allow a mean velocity of 1 meter per second for air through the recuperator.

$$\text{Mean temperature of air is, } \frac{1000 + 30}{2} = 515°\text{C.}$$

$$\text{Volume of air at } 515°\text{C} = 0.372 \times \frac{788}{273} = 1.06 \text{ cu. m.}$$

per second.

$$\frac{1.06}{1} = 1.06 \text{ sq. m. required cross sectional area of air flue.}$$

The spacing of the recuperator flues must be such as to allow a total area of 1.06 sq. meters for the air.

Size of air flue between recuperator and port, or burner.

$$\text{Volume of air at } 1000°\text{C} = 0.372 \times \frac{1273}{273} = 1.36 \text{ cu. m}$$

Allowed velocity = 3 meters per second.

$$\text{Required area} = \frac{1.36}{3} = 0.453 \text{ sq. m.}$$

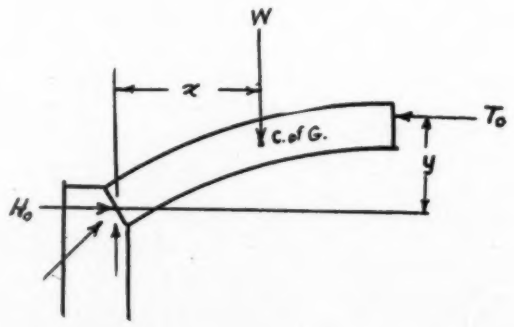
Size of port or burner.—Volume of air at 1000°C = 1.36 cu. m.

Volume of wet gas at 640°C = 0.953 cu. m.

There are two ports. Allowed velocity at the port = 8 meters per second.

$$\text{Required area of port} = \frac{1.36 + 0.953}{2 \times 8} = 0.145 \text{ sq. m.}$$

The size of the furnace was determined by following good furnace practice and keeping close to data obtained from furnaces in operation on a commercial scale. The furnace is 13 ft. × 37 ft. 10 in. inside. The arches are 4 ft. 4 in. wide and 4 ft. 10 in. high. The pillars are 15 × 18 inches. The crown has a rise of 2 feet.



To find the horizontal thrust T_o or H_o due to the arch, cut out a section of the arch and find the center of gravity. (See sketch.) Assume weight of arch brick = 150 lbs. per cu. ft. Width center to center of pillars = 5 feet 7 inches say

5.6 ft. Length of section of arch from spring line to center of keystone $= \sqrt{6.5^2 + 2.5^2} = 6.98$ say 7 feet.

$$T_o = \frac{\xi wx}{y} = \frac{7 \times 1 \times 5.6 \times 150 \times 3.6}{2.5} = 8{,}467 \text{ lbs.}$$

Detailed explanation of the above can be found in Baker, "A Treatise on Masonry Construction."

Cross section of tie rod needed between buck stays $= \frac{8467}{16000}$ = 0.529 square inch.

A 7/8 inch rod will answer the purpose. Its cross sectional area is .6013 inch.

Size of flue leading to chimney.—Volume of waste gases at $400°C = .612 \times \frac{673}{273} = 1.51$ cu. m.

Allow a velocity of 3 m. per second.

Area $= \frac{1.51}{3} = 0.5$ sq. m. $= 5.4$ sq. ft.

Size of chimney.—Coal per hour $= \frac{6{,}350}{24} = 265$ kg.

From Prechtl's table of stack measurements for regenerative furnaces.

Height = 31 m.

Inner width at top = .98 m. if square or 1.11 m. if round.

Inner width at bottom = 1.47 m. if square or 1.67 m. if round.

Base thickness = 0.65 m.

Top thickness = 0.18 m.

Mean diameter = 1.39 m.

Mean cross sect. = 1.52 sq. m.

Volume of enclosed gas column = 47.2 cu. m.

Theoretical velocity = 17.15 m. per second.

Real velocity = 5.72 m. per second.

Stack draft without flue resistance = 8.68 cu. m. per second.

Stack draft with flue resistance = 1.447 cu. m. per second. second.

Bibliography

U. S. Bureau of Mines, Bulletin No. 13.
Kent's Handbook.
Dralle "Die Glasfabrikation."
Damour "Les Chauffages Industrielles."
Baker "A Treatise on Masonry Construction."
Jüptner "Heat Energy and Fuels."

Decolorizing of Glass*

In the past few years there have been many complaints about the difficulty of decolorizing glass. There are many circumstances which influence the decolorizing of glass. The most important ones are mentioned here and are illustrated with examples from actual practice.

If insufficiently colorless glass is produced, it is necessary to give attention to the purity of the raw materials, especially with regard to the iron content. In the first place the sand must be considered, since it forms the main ingredient of every batch. Quartz sand should contain not more than 0.03 per cent iron oxide, when used for pure white crystal and optical glass. The same purity must be required of lime. Since it occurs in the batch in much smaller quantity than sand a little higher amount of iron is permissible; namely, up to 0.1 per cent iron oxide. Most varieties of lime show little less than 0.1 per cent, although there are several varieties with only 0.04 to 0.06 per cent iron oxide. In these two most important natural batch ingredients the iron content is determined by nature; from artificial products such as soda ash, potash and sulphate of lead oxide, a much lower iron content can be demanded. Especially soda ash and potash can be delivered practically free from iron. Salt cake and lead oxide can be delivered with an iron content of up to 0.01 per cent iron oxide. This can also be required of the rarer materials, or those used in small quantities such as saltpeter, borax, etc. If the iron content of the raw materials surpasses the definite limits mentioned above, it is impossible to produce colorless glass, even with the best decolorizing practice. Of course, if only an ordinary colorless glass is desired, the iron content of the raw materials may be higher and decolorizing can be resorted to; that is the iron green or iron yellow can be neutralized. However, not a colorless, but a gray glass is the result. The following examples may illustrate this further.

In a crystal glass factory the lead glass of average lead content suddenly showed a strong blue coloration. The blame was first laid to the lead oxide, which was therefore submitted for examination. However, it proved to be normal, had no insoluble residue and no coloring impurities such as copper, cobalt or nickel. The iron content was only about 0.01 per cent. After learning the result of the analysis the management of the factory stated that it had been observed that the color appeared when a special kind of manganese was used for decolorizing. This was also examined with the following result: 15.38 per cent insoluble residue, only 56.42 per cent manganese superoxide, and 2.35 per cent iron oxide. Nickel, cobalt and copper could not be found. The sample, therefore, was a rather low grade manganese, very high in iron. This manganese certainly was the cause of the coloration of the glass, directly since it increased the iron content, indirectly since on account of the low percentage of manganese superoxide the decolorizing effect became insufficient so that the iron color of the raw materials became visible. The lead glass, therefore, was not sufficiently decolorized by the low grade manganese. Almost double the amount should have been taken. However, in this way even more iron would have been added to the glass. Consequently such a manganese is not suitable for the decoloration of glass. When subsequently the glass was decolorized with nickel, the color disappeared.

*Allgemeine Glas- und Keram-Industrie. Vol. 15, No. 1. Translated for THE GLASS INDUSTRY.

Another example. A glass factory had made plate glass with a dark greenish tint from a batch with about two-thirds of salt cake and one-third soda ash. The iron content of the raw materials was as follows:

	Fe_2O_3
Sand	0.233%
Limestone	0.2-0.5%
Salt cake	0.051%
Soda ash	0.004%
Coal (for reduction)	0.3-0.6%

For a purely white glass raw materials of the following iron content were chosen:

	Fe_2O_3
Sand	0.011%
Limestone	0.045%
Soda ash	0.004%
Salt peter	0.01 %
Manganese	0.322%
Arsenic	0.0 %

This batch therefore was a soda ash batch of very pure materials which was decolorized with saltpeter, arsenic and manganese. Notwithstanding this the glass, made in open pots, showed some color. For this reason another decolorizing mixture of nickel oxide and sodium selenate was proposed. Good results were obtained with this mixture. It is true that it often happened that the glass appeared beautifully colorless when poured out, but became reddish brown in the lehr. But upon reheating, it again became colorless. It should be remarked here that it is very difficult to make purely colorless glass in the large plate glass pots, otherwise it would also be possible to make it in tanks. The differences in temperature of the furnace and of the waste gases, which has a great influence on decolorizing is very much in evidence in this case.

An important factor is the composition of the glass. In general the rule holds: Glass becomes more colorless and becomes easier to decolorize in proportion to its hardness; that is, the lower it is in alkalies the easier it can be decolorized. This applies especially to glass melted in open pots. In closed pots, however, colorless glass can be made with a softer batch, because the fire gases cannot exercise their coloring influence. The old idea that potash glasses are always more colorless than soda ash glasses proves to be correct in the present days of pure raw materials.

In a factory a very fine colorless glass had been made with potash, soda ash, limestone and barytes, using manganese as a decolorizer. It was made in closed pots. When open pots were used no colorless glass could be obtained with the above mentioned batch. When the batch was made harder, and manganese was replaced by nickel oxide and selenium, a colorless glass was again obtained.

It is clear that always the greatest care must be exercised in the storing and handling of raw materials and of the batches, so that no contamination with iron oxide can occur in any way. In one case it happened that the coloring of crystal glass could be explained by the cause above mentioned when it appeared that the tubes of the sand drying oven were covered with a heavy layer of rust, i.e., iron oxide. This, of course, caused coloring of the glass in spite of all attempts at decolorizing.

Decolorizing is an art which cannot be learned theoretically but which can only be acquired in practice. The action of decolorizers on iron oxide and other coloring substances can be explained in a way, and definite rules about firing, the addition or omission of other substances such as saltpeter and arsenic can be given. Even easier is the use of a number of ready-made decolorizers, obtainable in commerce. The writer has analyzed a number of them and has found in the majority of them nickel oxide and selenium, often with some manganese and arsenic. One preparation contained also so-called rare earths. Concerning one mixture it is stated with especial emphasis that it is free from selenium; with another the use of arsenic is especially prohibited, either in the batch or for fining the glass. In another case the use of arsenic is especially recommended.

From this it follows that for decolorizing the old rule applies that what is good for one is not necessarily good for another. Especially in the decolorizing of pure white crystal glasses and optical glass an experienced eye is needed. Every day the decolorizing must be corrected in accord with the results of the preceding melt, and must be changed accordingly. How and within what limits depends on the kind of color which the glass has shown, whether it is more yellowish, bluish or reddish. In this department of the glass industry co-operation between science and practice could give many good results.

The Use of Boric Oxide in Glass-Making*

By W. E. S. Turner†

ABSTRACT

Boric oxide behaves differently from other glass-making constituents in that the variation of physical properties is not progressively continuous with a variation in composition. With increase of boric oxide content in sodium borosilicate glasses, the refractive index (μd) rises to a maximum as also does the annealing temperature, while the coefficient of thermal expansion reaches a minimum and then rises. The durability, or resistance to water and hydrochloric acid reaches a maximum when the glass contains about 12% of boric oxide and subsequently falls off very rapidly. There is, accordingly, a limit to the usefulness of boric oxide in glass.

† Department of Glass Technology, The University of Sheffield, England.
*Jl. Am. Cer. Soc., Vol. 7, No. 5, May, 1924.

Introduction

The advantages attending the use of boric oxide in glass-making, whether as borax or boric acid, are widely known although less widely understood. It is not only in the manufacture of optical glasses, scientific, illuminating and heat resisting glassware that its importance has been recognized but it has also had its application in the preparation of bottle glass and of glass for tableware.

Advantages in General

The functions which recommend boric oxide in these different classes of glassware are several. In optical glasses

specific influences on the value of the refractive index and dispersion due to the oxide are made use of, while increase in durability is also gained. For scientific, illuminating and heat-resisting glasses the two most important properties which boric oxide bestows are an enhanced durability and a diminished coefficient of thermal expansion. A reduction in the viscosity of the molten glass is not the least important of the effects of this oxide, an effect of much value in glass-making practice.

This fluxing effect is the main reason for the employment of boric oxide or borax in the production of sealing-in glasses, for enamels, and generally as a medium for the application of pigments to glass. For the same reason, on doubt, it has found frequent use in some of the smaller glasshouses in England in which glass is melted from cullet, to which, in some cases, a small quantity of an alkaline salt, borax in particular, is added.

The object of using it in the production of colorless glass in tank furnaces does not appear yet to have been satisfactorily explained. We have found no evidence of any favorhave found, however, from our own experiments in this deable influence excited by it in the decolorizing process. We partment, that even small amounts, less than 1 per cent in the glass, may quite distinctly influence the viscosity of the molten glass while a definite enhancement of the durability simultaneously occurs. That this last statement is a fact is proved in the case of potash- and potash-soda-lead oxide glasses by the experiments of Hodkin and Turner.[1]

Effect of Boric Oxide not Continuously Additive

The question as to whether or not boric oxide continues to exercise its valuable functions in a glass in direct proportion to the amount present has been obscured in the past partly by general experience and partly by the deductions associated with the various additive rules deduced by Schott, Winkelmann and others. It certainly is the general experience that a continued increase in the proportion of silica in a glass produces a continuously increasing viscosity, a diminishing thermal expansion and an enhanced resistance to corrosion; and the same continuity of change in physical properties with variation of composition also appears to be true of many other well-known constituents of glass.

It was pointed out, however, by Zschimmer[2] in 1905, that when boric oxide was added to potassium silicate in continuously increasing proportions, the refractive index (μ_D) rose to a maximum value and then diminished. Recently it has been proved that a similar reversal occurs in several properties. Thus, we have shown[3] that not only does this apply to the refractive index of sodium borosilicates, but also to the density, the thermal expansion, the annealing temperature and the durability. These reversal effects are of the utmost importance, both technically and in industry; for it has been demonstrated that a reduction of thermal expansion or of liability to corrosion by increasing the percentage of boric oxide only holds good up to a certain point beyond which the thermal expansion rapidly becomes greater as also the extensiveness of corrosion by water and chemical agents. Any attempts, therefore, to improve heat-resisting glasses or chemical glassware by the introduction of ever-increasing percentages of boric oxide are doomed to failure; there is a limit beyond which deterioration, not improvement, occurs.

[1] Jour. Soc. Glass Tech., 4, 121 (1920).
[2] Zeitsch. Elektrochem., 11, 629 (1905).
[3] English and Turner, Jour. Soc. Glass Tech., 7, 155 (1923).

Effect of Boric Oxide on Resistance to Weathering

So far as weathering and resistance to chemical agents are concerned, boric oxide as an enhancer of resistance is something of an anomaly. Dralle[1] points out that the durability of a glass may be judged, in a rough and ready way, by the relative solubilities in water of the constituent oxides. Boric oxide, however, provides an exception to the rule. It is readily soluble in water and yet when present in commercial glasses it has been found to enhance, very greatly in many cases, their resistance to the attack of water and of chemical reagents. The explanation of this phenomenon has generally been sought in the assumption of the formation of a class of compounds known as borosilicates, or, alternatively, in the suggestion that boric oxide substitutes silica in the silicates, the increased durability being actually due to an increase of free silica. Both theories appear to the author to lack positive evidence to support them.

Indications of the unreliability of boric oxide as a never-failing source of resistance to weathering have not been wanting in the past, but they have not been widely known. There is no doubt that many old enameled glasses have suffered through the use of borax as the fluxing medium whereas those in which lead silicate has been employed have withstood the ravages of time. Schaller states that boric oxide added to sodium silicate at first diminishes the attack by water but later increases it. Sullivan and Taylor, in their account of Pyrex glass, stated that they found a limit to the usefulness of boric oxide as beyond a certain percentage the glass containing it rapidly fell away in durability.

So far as the general problem of durability is concerned an exhaustive experimental study of the behavior of a large number of commercial chemical glasses led the writer with J. D. Cauwood[2] to the conclusion that, "Boric oxide increases the resistance of glass towards water, although it is probable that beyond a certain value (about 12 molecules per 100 molecules of silica), this effect declines. Boric oxide weakens the resistance of a glass towards alkali and hydrochloric acid."

Recently it has been found possible to test this conclusion in a more direct manner, and based on work carried out in this laboratory by Miss V. Dimbleby, evidence that it is substantially true has been forthcoming.

[1] "Die Glasfabrikation," 1911, p. 85.
[2] Jour. Soc. Glass Tech., 2, 233 (1918).

Recent Progress in the Field of Fuel and Combustion

Recent progress in the field of fuel and combustion was discussed in a paper, by R. T. Haslam and E. W. Thiele, presented at the recent meeting of the American Chemical Society at Washington, D. C.

On the basis of the replies to a questionnaire sent out to representative workers on fuel throughout the world, and of a survey of the literature, the authors undertake to indicate the phases of fuels and their combustion which are receiving attention from scientists and engineers.

The Glass Industry

The First Technical Trade Journal Devoted Primarily to Glass Technology, Engineering, Raw Materials, and Glass Factory Equipment and Operation.

Published Monthly by the
GLASS INDUSTRY PUBLISHING COMPANY, INC.
50 Church Street, NEW YORK

Telephones { Cortlandt 2465 / Cortlandt 5618 — Cable Address, Glasdustry

J. B. KRAK, Technical Editor

Subscription Price.....$2.00 a Year
Single Copy.....20 Cents

THE GLASS INDUSTRY circulates extensively among American and foreign glass manufacturers, their business executives and technical and factory operating staffs.

ADVERTISING RATES SENT ON REQUEST

Vol. 5 NEW YORK, JUNE, 1924 No. 6

CONTENTS

	Page
Flat Glass	99
Composition of Horak Glass	99
Design of a 14-Pot Recuperative Glass Furnace	105
Decolorizing of Glass	109
The Use of Boric Acid in Glass-Making	110
Editorial:	
Protecting Our Export Trade	112
Technical Consultation Service:	
Seeds in Glass	112
Recent Patents	113
New Books	114
The Glass World and What It Is Doing:	
Big Companies in Patent Agreement	115
Society of Glass Technology	115
First Quarter's Plate Glass Production	115
New Glass Sand Plant	115
Fourcault Factories Make Good Start	115
Chimney Workers' Wages Reduced	115
Owens Bottle Quarterly Report	115
Glass Container Association Election	116
Verified News of Trade Activities	116
Coming Meetings	117
Inquiries Received	117
Stock Quotations	117
Current Prices of Glass-Making Materials	118
Monthly Summary of United States Foreign Commerce in Glass	118

CLASSIFIED BUYERS' GUIDE, PAGE 18
INDEX TO ADVERTISEMENTS, PAGE 20

Readers of THE GLASS INDUSTRY in the United States and elsewhere are requested to favor the Editor with any information available from time to time concerning developments in their own or other fields which would be of general interest to the industry. Authoritative facts about new glass manufacturing projects, re-organizations, new factory construction, new processes and equipment, raw materials, manufacturing and market conditions, personal items, and other appropriate subjects would be welcomed.

Those experienced in the practical, technical or executive activities of glass manufacturing who are qualified and willing to lend their aid to the upbuilding and progress of the industry by giving from their store of knowledge to others, are invited to submit for publication articles on any subjects relating to glass which would be of interest and value to our readers. The authors of accepted articles of this kind will be compensated at usual rates.

Protect Our Export Trade

During the past few years a large amount of time, money and energy has been expended through government agencies and private interests in efforts to extend and improve our foreign trade. A substantial portion of the taxpayers' money is devoted to this purpose. The Department of Commerce maintains a large staff of commercial representatives at many foreign points, collects and distributes to exporters a great deal of useful information and aids the American business man in every possible way. Various export associations also engage in the same kind of work.

But of what avail are these persistent efforts to build up a profitable and permanent foreign trade if, after orders are obtained by a manufacturer, the goods shipped are of inferior quality. Not infrequently such is the case and the effect on the general reputation of American goods is deplorable. A case in point which recently came to our attention is that of a South American importer and large user of bottles whose representative is now in this country. Practically all of his orders are placed in Germany. When questioned as to why American goods are passed by, the agent replied that they had been given a fair trial, but that breakage losses in unloading, handling, filling and packing amounted to nearly eight per cent of the total, while German-made bottles undergoing the same operations showed a loss of only one-half of one per cent.

Taking this fact into consideration, it was pointed out, the importer could afford, if necessary, to pay a higher price for German bottles than those of American make. Here is a case where a shipment of inferior goods has done injury to the reputation of American glassware and shut it out from a market which might have been made a profitable one.

If the exportation of glass is to be increased it is essential that no glassware of inferior quality be shipped out of the country.

Another practice which has been detrimental to the export trade and which has, on several occasions, brought forth criticisms from foreign purchasers of American glass-making machinery is that of taking orders without any guarantee that the machinery will be properly installed and efficiently operated. In the past a number of cases have come to light where American machinery exactly like that in successful use in this country has been installed abroad but on account of being left to the tender mercy of inexperienced operators has proved unsatisfactory and has been thrown aside.

If makers of American machinery would refuse to accept an order until assured that their machines would be properly operated they would, in the long run, be better off than when running the risk of having the reputation of their machinery injured through lack of a thorough understanding of it on the part of the buyer.

AUTOBIOGRAPHY OF DR. JOHN A. BRASHEAR. Some time during the year an autobiography of Dr. John A. Brashear, the famous scientist and lens manufacturer, will be published under the auspices of the American Society of Mechanical Engineers, of which he was a past-president.

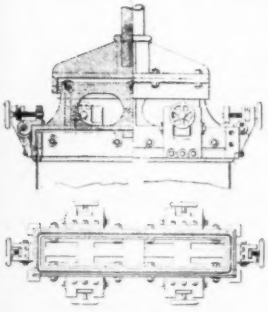
Recent Patents

NEW INVENTIONS DESIGNED TO IMPROVE GLASS AND THE MEANS OF PRODUCING IT

Copies of United States Patent Specifications may be obtained from the Commissioner of Patents, Washington, D. C. Price 10c each

Glass-Drawing Machine. U. S. 1,491,749. Apr. 22, 1924. Arthur Houssiere and Jules Houssiere, of Lancaster, O.

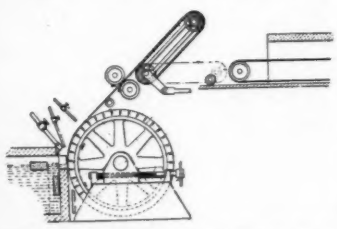
The object of the invention is the provision of a glass-drawing machine particularly adapted for drawing sheet glass in the shape of a rectangle having slightly rounded corners whereby two narrow sheets and two substantially wide sheets of glass can be drawn simultaneously, the rounded corners serving as a guide for separating the several sheets.



Another object of the invention is the provision of a glass drawing machine comprising a holder supporting a carriage provided with an inner and outer jaw member, the inner jaw member being preferably stationary with respect to the carriage while the outer jaw members are suitably mounted upon the carriage for movement toward and away from the inner jaw member whereby the jaw members are inserted into the molten glass in an open position and the outer jaw members then moved toward the inner jaw members for clamping a portion of the glass between the jaws to provide a starter for the glass whereby a slow movement of the carriage upwardly will draw the glass from the molten tank in an even layer.

Process and Apparatus for Drawing Sheet Glass. Re. U. S. 15,821. Apr. 22, 1924. Julian H. Kendig, of Edgewood, Pittsburgh, Pa., assignor to the Libbey-Owens Sheet Glass Company, of Toledo, O.

The inventor claims a process of making sheet glass which consists in drawing a plastic sheet of glass directly from the surface of a body of molten glass upwardly, while plastic, over a roll having a carbonized supporting surface disposed so as to support the glass substantially from the point of emergence from the body of glass to a remote point, in turning the roll so that the surface thereof which is in contact with the glass has relative movement with respect to the glass while the glass is being drawn.

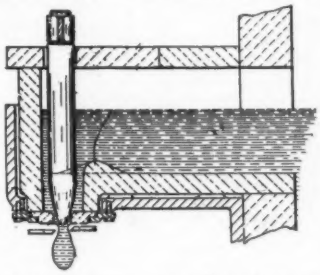


Machine for Working on Glass. U. S. 1,492,602. May 6, 1924. Walter J. Leveridge, of Mount Vernon, and Paul Schwerin, of New York, N. Y., assignors to Western Electric Company, Incorporated, of New York, N. Y.

The invention in general comprises a platform on which is mounted a mold portion to which the glass parts, cut to desired length, are fed, one after the other. Adjacent this mold portion are a plurality of guides through which the wires to be inserted in the glass are fed by semi-automatic means. Adjacent this mold portion are a plurality of flames which are so directed as, at the proper moment, to heat certain portions of the glass to a point where it is soft. At this time, the feeding means is operated to force a plurality of wires up to a point to contact with the fused glass and then a slow-acting feed mechanism is brought into play to gradually force the wires into the glass to a definite depth. The feeding mechanism is then withdrawn and in the act of withdrawing cuts to a required length the portion of the wires embedded in the glass and at the same time these feeding mechanisms, being one way acting, slide along the remaining wires so that they are left in position ready to be fed forward. Immediately after the feed mechanism has been retracted, an automatic device ejects the prepared glass into a suitable channel leading to a hopper.

Glass Feeder. U. S. 1,490,930. Apr. 22, 1924. Richard La France, of Toledo, O., assignor to the Owens Bottle Company, of Toledo, O.

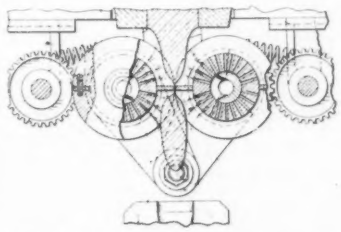
This invention relates to glass feeding apparatus and more particularly to automatic feeders of the type in which a vertically reciprocating plug or plunger controls the periodic discharge of molten glass through an outlet opening in the bottom.



The inventor claims in the combination of a tank or furnace, a forehearth or boot extending therefrom, and comprising a vertical front wall, the boot formed with a well or passageway extending downward through the floor of the boot, the front wall of the well being substantially in line with the inner face of the front wall of the boot, a reciprocating plunger projecting downward into the boot to control the flow of glass therefrom, and a hump projecting upward from the floor of the boot below the normal level of the glass, the hump being immediately behind the plunger and extending laterally beyond the side surfaces of the plunger in position to deflect the flowing glass to opposite sides of the plunger.

Means to Produce Charges of Glass. U. S. 1,490,946. Apr. 22, 1924. Leonard D. Soubier, of Toledo, assignor to the Owens Bottle Company, of Toledo, O.

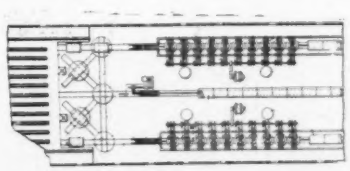
This invention relates to means for feeding molten glass from a container and forming it into gobs or mold charges of suitable size, shape and condition for entering the molds of a glass forming machine.



The inventor claims the combination with means to flow a stream or column of molten glass, of a pair of forming rolls arranged to embrace the flowing glass and formed with shaping or molding recesses in their peripheries, and means to supply burning gas to envelop the glass as it passes between the rolls.

Apparatus for Surfacing Sheets. U. S. 1,492,974. May 6, 1924. John H. Fox, of Pittsburgh, Pa., assignor to Pittsburgh Plate Glass Company.

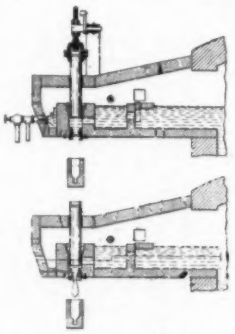
The inventor claims in combination in a grinding and polishing apparatus, a pair of parallel tracks, cars for carrying the sheets to be surfaced along such tracks, a series of grinding devices arranged along the forward portion of each of the tracks, a series of polishing devices arranged along the rear portion of each



of the tracks, a return track between said pair of tracks, and transfer means between the three tracks at their adjacent ends, so that cars from the rear ends of the pair of tracks may be shifted to the return track, and cars from the front end of the return track may be shifted to the pair of tracks.

Glass-Feed Mechanism. U. S. 1,491,067. Apr. 22, 1924. John Rau, of Indianapolis, Ind.

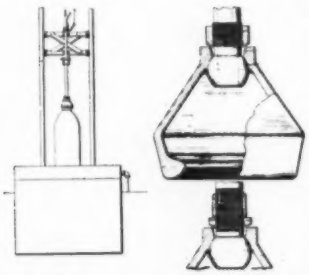
The main object of this invention is to effect an improved discharge spout and feeding mechanism for automatically feeding distinct gathers of glass from the tank direct to the mold whereby the molten glass discharge into the mold will be maintained at a substantially even temperature and prevented from becoming chilled on one side and causing the discharged gob or globule-like mass to be bent or formed out of proper shape and a deformity produced in the glass ware.



Another feature of the invention is the arrangement of the cut-off valve for the passage between the glass chambers for preventing the flow of glass therethrough when it is desired to empty the discharge chamber.

Glass-Drawing Device. U. S. 1,492,549. Apr. 29, 1924. Harry E. De Vaughn, of Morgantown, W. Va., assignor to United States Window Glass Co., Morgantown, W. Va.

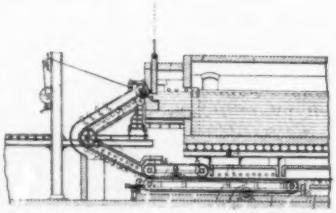
This invention is a bait for drawing window glass cylinders by the machine method, and consists of a modification of the device disclosed in the copending application Ser. No. 651,309, filed July 13, 1923.



One of the objects of the invention is to provide a bait having a universal joint connection with the bait-stem, whereby the gravity inherent in a freely movable suspended bait, may be utilized to counteract the tendency of the cylinder to travel over the surface of the bath during the drawing operation.

Process and Apparatus for Making Sheet Glass. U. S. 1,492,975. May 6, 1924. John H. Fox, of Pittsburgh, Pa., assignor to Pittsburgh Plate Glass Company.

The invention relates to a process and apparatus for producing sheet glass having fire finished surfaces which require no smoothing or polishing.



The inventor's claims include the process of making sheet glass which consists in conducting molten glass laterally from a relatively large body, rolling or sizing the sheet to uniform thickness, exposing the upper side of the sheet to a fire finishing heat, leading the sheet around a curve to bring the finished side down, permitting such finished side to harden and supporting such finished side while applying a fire finishing heat to the other side of the sheet, all while the sheet moves continuously forward.

New Books

MODERN GAS PRODUCERS, by N. E. Rambush, M. I. Chem. E. 564 pages, 356 illustrations, plates and tables, cloth binding. Published by Benn Bros., Ltd., London. D. Van Nostrand Co., New York. Price, $15.

The author, intimately connected with the production of producer gas, divides his treatise into sections devoted to: theory, plant, working producer gas plants and finally an outline of producer gas utilization. The material dealing with producer gas manufacture and plant design is especially detailed, and space is devoted to setting forth the specific features of each design, rather than to the commercial development of each type of plant.

Receiving this book in *Chemical and Metallurgical Engineering*, W. B. Chapman, the Chapman Engineering Co., says:

"Before this interesting treatise appeared there were a dozen books on the subject of producer gas and gas producers —now there is but one. Heretofore, books about producer gas have neglected, or missed altogether, the most important phase of this subject, which is the making of raw gas in mechanical producers for large heating operations. Mr. Rambush treats this, as well as all other aspects of the subject, comprehensively and ably....."

While this book was being prepared two types of mechanically ashed producers, not treated in the book, were being developed in America and are now on the market.

DER WAERMEFLUSS IN EINER SCHMELZOFENANLAGE FUER TAFELGLASS. (The flow of heat in a window glass furnace.) By Dr. Ing. Heinrich Maurach, 10 x 7 inches, 96 pp., 28 illustrations and one plan. Published by R. Oldenbourg, Munich and Berlin.

This volume was written as a result of a study made under the auspices of an institution organized for the purpose to give technical advice to glass factories with regard to the efficient use of fuel.

This advisory bureau (Waerme technische Beratungstelle der Deutschen Glasindustrie in Frankfurt) has from the time of its foundation done most valuable work to promote more efficient use of heat in the glass industry. Dr. Maurach, who is director of the bureau, has investigated the heat balance of a glass furnace. The measurements have been made with much care and accuracy and the results have been put into the form of tables. It appeared that only 12.8 per cent of the heat supplied was used effectively in the actual melting and fining of the glass, and for keeping it at the necessary temperature, a figure quite in agreement with results based on theoretical computations. The book is well worth the attention of glass technologists.

THE CALCO HANDBOOK OF RECUPERATION, by G. D. Mantle, Engineer. The Calorizing Company. Size 8½ x 11. Thirteen sections. Price $3.00. Published by The Calorizing Company, Pittsburgh, Pa.

This is a very handsome volume containing many illustrations, blue prints and a large number of charts. In it are set forth the reasons and advantages of recuperation, the types of heat salvage apparatus, the principles of combustion, the improvement of combustion by recuperation, the influence of recuperation upon flame temperature, the theory of recuperator design, the calorizing process and the various forms of recuperators made by the company. Of especial interest to glass makers is the application of the Calco recuperator to glass melting furnaces.

THERMAL-CONDUCTIVITY METHOD FOR THE ANALYSIS OF GASES, by P. E. Palmer and E. R. Weaver, Chemists, Bureau of Standards. Technologic Paper of the Bureau of Standards No. 249. 65 pp. 40 illustrations. Price 20 cents. Sold by the Superintendent of Documents, Government Printing Office, Washington, D. C.

This publication is the result of several years' study and experimental work by scientists of the Bureau of Standards, having the object to develop an automatic method of analysis of gas mixtures based upon the difference in the thermal conductivity of gases.[1]

This book deals with the physical principles upon which the method is based, the possible applications of the method, the results obtained in its actual application and the details of construction, calibration and care of the apparatus employed.

[1]Compare Vol. 4, No. 7, p. 136 (July, 1923).

The Glass World and What It Is Doing

News of the Industry

Big Companies in Patent Agreement

The dispute between the Owens Bottle Company, Toledo, O., and the Hartford-Empire Company, Hartford, Conn., over rival patents on plug or gob feeder and glass forming machines has been amicably settled on a basis mutually agreeable to both parties.

In the settlement each company grants to the other a license under its patents in the plug or gob feeder and forming machine field, Hartford-Empire Company being given the exclusive right to grant sub-licenses under the Owens company patents. Hartford-Empire Company acknowledges the validity of the Lott patents, containing broad claims and having from 14 to 16 years yet to run. This settlement does not in any way involve the Owens suction type machine, the rights to which remain exclusively in The Owens Bottle Company. The litigation between the parties now pending in the United States District Court at Pittsburgh will be disposed of shortly. Each of these companies owning important patents will now be free to develop its feeders and forming machines without fear of the expense and uncertainty of continued patent litigation. The industry will have the benefit of the latest and most improved productive machinery without the annoyance and danger of conflicting and uncertain claims for infringement and the unauthorized use of patent rights by machine builders and bottle manufacturers will be stopped. It is also announced that at practically the same time and in view of the foregoing settlement the Illinois Glass Company has entered into a new general agreement with the Hartford-Empire Company providing not only for the extension of its present licenses of Hartford-Empire machines, but also for certain valuable and important non-exclusive rights to use machines developed in the future by the Hartford-Empire Company.

Society of Glass Technology

The seventh annual general meeting of the Society of Glass Technology was held in Sheffield on April 16th, 1924, the President, Prof. W. E. S. Turner, D. Sc., in the chair. Col. S. C. Halse, C. M. G. (Messrs. J. Lumb & Co., Ltd., Castleford), was elected president in succession to Prof. W. E. S. Turner. The other vacancies arising were filled as follows: Vice-presidents: F. G. Clark (Messrs. Beatson, Clark & Co., Ltd., Rotherham), R. L. Frink (Glass Research Association, London). Members of council: H. A. Beatson, W. R. Dale, J. Moncrieff, W. J. Rees, B. Sc. Tech., F. I. C., J. H. Steele, J. P., and H. Webb. Honorary treasurer: J. Connolly. American treasurer: Wm. M. Clark, Ph. B. Honorary secretary: S. English, M. Sc. Auditors: Ed. Meigh, M. Sc., Dennis Wood, F. S. A. A.

The annual report and accounts for 1923 showed that year to have been a happy and successful one. The foreign membership continued to increase, numbering 190 out of 615 at the end of 1923. Of these, 109 were resident in the United States. Altogether the society was connected by membership with no fewer than 17 countries. Prof. Henry Le Chatelier, Paris, was elected an Honorary Member of the society.

First Quarter's Plate Glass Production

The total production of polished plate glass by American manufacturers for the first quarter of 1924 was reported in May by P. A. Hughes, secretary of the Plate Glass Manufacturers of America, to be 22,005,629 square feet. The figures for the corresponding period of 1923 were 21,076,741. This shows the amount produced in the first quarter of this year to be almost a million square feet in excess of that made in the first quarter of 1923.

The production of plate glass in the United States has shown a steady increase since 1921, during which year the production was 53,578,682 square feet; in 1922, 76,678,207 square feet were produced, while in 1923, the production reached a total of 89,069,441 square feet. It is estimated that the production for 1924 will be over 100,000,000 square feet, which is by far the greatest amount ever produced in this country in one year.

New Glass Sand Plant

The Pennsylvania Glass Sand Company, Lewiston, Pa., has announced through Wm. J. Woods, assistant general manager, that construction work on a new glass sand plant at Mapleton, Pa., was started about April 20. The entire plant is to be constructed of concrete and steel, and will be strictly fireproof. It will be equipped with the very latest machinery and will have a daily capacity of 1,500 tons of No. 1 glass sand.

New methods of preparing, washing and screening the sand will be installed.

Contracts for completing the work as well as for the machinery have already been placed and it is expected this plant will be ready for operating early next year.

The deposit from which the raw material will come is known as Oriskany sand stone, which is one of the purest deposits of quartz rock silica known.

Fourcault Factories Make Good Start

The Blackford Window Glass Company, Vincennes, Ind., under the management of Frank Bastin, put their new Fourcault plant into operation on May 19. This plant is equipped with eight Fourcault machines.

The Clarksburg Glass Company, Clarksburg, W. Va., is installing eight Fourcault sheet glass drawing machines in its Adamston plant, which has been converted to operate under the Fourcault method. This will give Clarksburg two plants operated by this system, the other plant being the American Sheet Glass Company, whose factory was completely described and illustrated in the April issue of this journal.

Within the last five months four plants equipped with the Fourcault system have been put into operation including, in addition to the two mentioned above, the Continental Flat Glass Company, Shreveport, La., and the Quertinmont Glass Company, Fairchance, Pa.

Chimney Workers' Wages Reduced

A reduction of 42 per cent in the scale of piece-work prices has been accepted by the chimney department of the American Flint Glass Workers' Union. This cut in wages has been partly offset by removing the limit on production. It is reported by Morgantown, W. Va., factories that before the reduction was made the average worker was able to earn about $11 a day, while under the new scale wages will average from $7.50 to $9 a day. Summer dullness in the lamp chimney business and competition from non-union plants working on an unlimited basis is said to have led to the adoption of the lower scale.

Owens Bottle Quarterly Report

An official statement of the Owens Bottle Company covering the first three months of the year shows a net profit for the company and its subsidiaries amounting to $802,454.60. This is against a net profit in the first three months of 1923 of $907,360.

The statement shows from manufacturing profit and royalties for the three months $1,308,344.27. Cash dividends, in-

terest and other income amounted to $185,455.61, or a total income of $1,493,789.88.

From this are deductions of general, selling and contingent expenses amounting to $576,335.28; net earnings before deducting federal income tax amount to $917,454.60. Estimated federal income tax amounts to $115,000, leaving a net profit of $802,454.60 for the quarter.

Glass Container Association Election

At the fifth annual meeting of the **Glass Container Association** held at Atlantic City, N. J., the following directors were nominated as follows: P. C. Doyle, T. L. Briggs, J. H. Graham, George W. Yost, and F. E. Baldwin. The directors then elected F. F. Ferguson of the Illinois Glass Company, Alton, Ill., as president; A. F. Brady of the Hazel-Atlas Glass Company, Wheeling, W. Va., first vice-president; P. I. Heuisler of the Maryland Glass Corporation, Baltimore, Md., second vice-president and R. E. Walker of the Turner Bros. Company, Terre Haute, Ind., secretary and treasurer.

Verified News of Trade Activities

Irving E. Adams, consultant on glass problems, has moved from 623 North Spring Garden St., Ambler, Pa., to 340 Spring St., Reading, Pa.

The business of **H. Perilstein,** glass distributor, 4119 Leidy Ave., Philadelphia, Pa., has been chartered under the laws of Pennsylvania with a capital of $100,000.

The Orange Glass Company, Inc., Newark, N. J., has been incorporated with a capital of $40,000 to manufacture glassware. Jacob Fischel is one of the incorporators.

The Buckeye Window Glass Company, Columbus, O., has been organized with a capital of $1,500,000 by Chas. E. Bartram, Gerald C. Scott, Raymond Link, Chas. E. Bartram, Jr. and E. N. Huggins.

George D. Willetts, formerly superintendent of the refractories plant of the Willetts Company, Pittsburgh, Pa., has taken charge of the Charleroi, Pa., refractories plant of the Pittsburgh Plate Glass Company.

The Vitro Manufacturing Company offices have been moved from the Bessemer Building to rooms 927 and 928 Fulton Building, Pittsburgh, Pa. The company manufactures glassmakers' chemicals and ceramic materials.

The Paramount Window Glass Company plant at Salem, W. Va., was sold at public auction on May 23. The plant was built in 1920 at a cost of $225,000 and made its last run of glass in 1923 under the management of M. Wardner Davis as trustee.

The J. E. Marsden Glass Works, Ambler, Pa., has completed the erection of an addition to its factory to be used for a lehr and packing room. This, as reported by J. E. Marsden, Jr., will increase the capacity of the plant about 25 per cent.

The *Sand Springs* (Okla.) *Leader* reports that **Kerr, Hubbard, & Kelly** has purchased automatic blowing machinery for installation in their plant. On account of conditions in the lamp chimney market the new equipment will be devoted to other lines.

Ray F. Schneider, of the **Williams Patent Crusher & Pulverizer Company,** manufacturers of crushers and pulverizers for glass, metal, etc., announces that the San Francisco, Cal., office, showrooms and warehouse have been moved to new quarters at 415-5th street.

The Western Glass Company, Streator, Ill., is reported to have awarded a contract to the Union Iron Works, Los Angeles, Cal., for a group of new buildings at Fullerton, Cal., consisting of eight steel frame buildings, including an administration building, 60 x 60 ft.; polishing, cutting and storing plant, 200 x 200 ft.; cooling building, 40 x 170 ft.; casting hall, 80 x 140 ft.; furnace room, 80 x 80 ft.; tank shop, 40 x 80 ft.; machine shop, 40 x 80 ft., and warehouse, 40 x 80 ft.

Robert L. Frink, the well known American authority on glass, who went to England several years ago to take the directorship of the Glass Research Association was elected vice-president of the Society of Glass Technology at a meeting held in Sheffield, England, April 17.

The Hocking Glass Company, Lancaster, O., resumed the production of glass about the middle of May in the plant which was almost entirely destroyed by fire about two months previously. One tank is in operation with two feeders and four machines working on light ware.

W. L. Bampton, treasurer of the Amsler-Morton Company, Pittsburgh, Pa., has resigned and returned to his former home in Philadelphia. **P. L. Geer,** secretary of the company will succeed Mr. Bampton as treasurer and will also look after the sales and have charge of the Pittsburgh office.

The Libbey-Owens Sheet Glass Company, Toledo, O., has declared regular quarterly dividends of 50 cents on the common and $1.75 on the preferred, both payable June 2 on stock on record May 22. The company elected to its board, Marshall Field, John H. Fulton, Chas. V. Rich and Edw. P. Currier.

The Onondaga Mirror and Glass Works, dealers in building glass, automobile windshield glass, etc., has moved to larger quarters at 230-232 East Water St., Syracuse, N. Y., where they will have better facilities for transacting their business which also includes the silvering, resilvering and beveling of plate glass mirrors.

The Swinton Art Glass Company, Toledo, O., will move on July 1 from 724 Fifteenth St. to Belmont Ave., that city, where the company recently purchased a new building at a cost of $25,000. D. H. Swinton reports that when located in the new quarters they expect to have one of the most modern art glass plants in the country.

The W. J. Schoonover Glass Company, with warehouses in Scranton, Wilkes-Barre and Allentown, Pa., has purchased property on Eagle Street, Utica, N. Y., and construction has been started on a new building to be used for the manufacture of plain and beveled mirrors and for resilvering. A warehouse will also be erected.

Application has been made by Walter J. Benz, Julius Kim and Louis L. Lechner for a Pennsylvania charter of incorporation for the **Sanitary Cover Company** to permit them to manufacture, buy, sell and trade in metal, glass and wood covers, tops and containers, etc. M. J. Kraus, Ellwood City, Pa., is solicitor for the application.

The Pennsylvania Plate Glass Company was incorporated at Wilmington, Del., about the middle of May with a capital of $7,500,000. W. A. James, a prominent business man of Kane, Pa., is reported to be one of the leading factors in the enterprise. Unconfirmed reports state that the company will erect a large plant at James City, near Kane.

Russell B. Cressman, 200 Fifth avenue, New York, has become general sales agent for the Tufglass battery trays for use underneath radio batteries to save carpets and rugs from damage. The tray is made of acid-resisting glass and measure 8½ by 9 inches. Mr. Cressman is desirous of getting in touch with dealers and agents who can handle this product.

The Helmerich Glass Company, 719 Fulton street, Chicago, Ill., has been incorporated with a capital of $20,000 to manufacture and deal in glass and glass products. The incorporators are: F. J. Drehobl, Joseph E. Flanagan, M. J. Eberhardt and Eugene Kohler Schuyler, Ettelson and Weinfeld, Illinois Merchants' Bank Building, Chicago, are correspondents.

The plant of the **Royal Window Glass Company,** Grafton, W. Va., which was recently equipped with modern glass making machines but which was forced to close due to financial difficulties, was sold at public auction on April 28 to the highest bidder, Dr. O. S. Campbell, for $30,050. The only other bidder was the Lafayette Glass Company of Clarksburg, W. Va. It was estimated that the plant originally cost $200,000.

The Memphis Glass Company, 391 Madison Ave., Memphis, Tenn., has been incorporated by Walter B. Ward, R. L. Defries, D. G. Dillon, N. B. Ward and H. A. Carroll.

The Standard Plate Glass Corporation temporary certificates for 7 per cent cumulative preferred stock and temporary certificates for common stock without nominal or par value have been admitted to trading on the New York Stock Exchange.

The Standard Plate Glass Corporation, Pittsburgh, Pa., has obtained control of the Watson Paint and Glass Company, Pittsburgh, Pa., the Zenn Paint and Glass Company, Youngstown, O., and the Bison Paint and Window Glass Company, Buffalo, N. Y.

The Pittsburgh Plate Glass Company, Pittsburgh, Pa., has announced that another tank will be built immediately at the company's Creighton, Pa., plant. This unit will be equipped to produce plate glass by the new "continuous flow" method which has been thoroughly tried out at Creighton. With the newly authorized addition this plant will have an annual capacity of about 20,000,000 square feet of glass.

H. H. Valiquet, for 18 years chief engineer for the Chicago Division, B. F. Sturtevant Co., will join Kirk & Blum Co., Cincinnati, O., as chief engineer. Mr. Valiquet is an authority on blow-pipe engineering and equipment requiring fans and fan apparatus and will specialize in dust collecting, pneumatic conveying systems, ventilating and cooling systems, etc.

The Standard Glass Manufacturing Company, of Bremen, O., at a meeting held in Lancaster, O., elected the following officers and directors: I. J. Collins, president; Louis Fritz, vice-president; Thomas C. Fulton, treasurer; B. E. Factor, secretary and E. B. Good, director. The leading interests in this company are closely associated with the Hocking Glass Company, of Lancaster. The company's glass cutting plant is now in operation.

The Davies Glass and Manufacturing Company, Martins Ferry, O., has been shut down owing to lack of working capital. The report that a receivership had been asked for was denied by the officials of the company. Creditors are attempting to effect a settlement without recourse to litigation. Some time ago it was reported that W. E. Hunter, formerly of the Economy Glass Company, Morgantown, W. Va., had become interested and would take over the general management of the Davies plant, but the arrangements were cancelled.

Coming Meetings

The next meeting of the **American Society for Testing Materials** will be held at Atlantic City, N. J., June 24 to 27.

The annual meeting of the **National Glass Distributors' Association** will be held in Pittsburgh, Pa., during December, 1924.

The next **National Foreign Trade Convention** will be held at Boston, Mass., June 4, 5 and 6.

The Summer meeting of the **American Ceramic Society** will take the form of a four weeks' trip to the Pacific Coast, leaving Chicago on July 21 and returning about August 19. Stops will be made at various points and ceramic plants inspected. Many places famous scenically, in Washington, California and Colorado, will be visited.

The annual meeting of the **National Ornamental Glass Manufacturers' Association** of the United States and Canada will be held at New York, July 7 and 8.

The **American Association of Flint and Lime Glass Manufacturers** will hold their annual meetings at the Marlborough-Blenheim Hotel, Atlantic City, N. J., on July 14. The **National Association of Manufacturers of Pressed and Blown Glassware** will meet at the same place on July 15 and on the 16th will meet a committee of the **American Flint Glass Workers' Union,** whose convention will begin June 30, in a joint conference to consider the wage scales in the various branches of the industry for the ensuing year.

The Atlantic City convention of the **Glass Bottle Blowers' Association** of the United States and Canada will begin on July 7.

Inquiries Received

For further information address THE GLASS INDUSTRY

197. We would like to be put in touch with the manufacturers of machinery for the production of sheet glass. This machinery is required for use in Brazil. (May 19.)

198. Kindly give us the names of firms which could supply carborundum wheels and carborundum abrasive to be used in beveling plate glass, particularly for cutting bevels and roughening edges. (May 7.)

199. We would like the names of manufacturers of glass knobs and drawer pulls, plate or drawn sheet glass push plates, glass cane for towel bars and plate or sheet glass shelving. (May 7.)

200. Can you give us the names of manufacturers of iridescent glassware such as is sold in the ten and twenty-five cent stores. Also manufacturers of opal pots and other kinds of pots, possibly in fancy styles, suitable for vanishing creams. (April 29.)

201. Will you kindly advise us whether there is a machine made for manufacturing embossed glass letters. (May 12.)

202. We would like the names of manufacturers of equipment for sand blasting plate glass. (May 14.)

203. Where can we obtain production and employment statistics and cost calculations, in line of cutting, beveling, edging (not etching) and silvering of window and plate glass?

206. Kindly put us in touch with manufacturers who specialize in furnishing small beveled glasses, oval in shape, but not a true oval, approximately 1½ in. long by 1 in. wide. (May 26).

Stock Quotations

(Reported by Moore, Leonard & Lynch, Frick Bldg., Pittsburgh, Pa.)

PITTSBURGH STOCK EXCHANGE, MAY 23, 1924

	BID	ASK	LAST
American Window Glass Machine common	88	89	80
American Window Glass Machine, preferred	92¾	94	93½
American Window Glass, preferred	108½	109	109
Pittsburgh Plate Glass	230	235	232½
U. S. Glass	...	23	23
Standard Plate Glass, common	32½	33½	33⅜
Standard Plate Glass, preferred:			
Cumulative	89½	90½	90
Prior	99½	100	100

Glass stocks on the Pittsburgh Stock Exchange reflected the existing inactive condition of industry. The stagnation was not peculiar to the glass industry but affected all business in general. A more limited consumption led to a sporadic demand and quite a few plants expect to shut down during July to give all their employees a vacation at the same time and enable the plants to make needed repairs. It is expected that when operations start again in August there will be enough business to warrant continuous operation the balance of the year. Production of all kinds of glass except plate glass declined during the last month.

WHEELING STOCK EXCHANGE, MAY 23, 1924

	BID	ASK	LAST
Hazel Atlas	...	33	33
Imperial Glass	...	90	90
Fostoria	140	...	150
Central Glass	...	110	110

The Wheeling issues maintained their recent price levels during the last month, with the exceptions of Hazel-Atlas which sold down to 30 on considerable volume but recovered to 33 closing at a net gain of 1½ points for the month.

TOLEDO STOCK EXCHANGE, MAY 23, 1924

	BID	ASK	LAST
Owens Bottle Machine, common	42½	43	42⅞
Libbey-Owens Sheet Glass, common	85	90	80
Libbey-Owens Sheet Glass, preferred	108 ex. div.		

Current Prices of Glass-Making Materials

Quotations furnished by various producers, manufacturers and dealers

May 23, 1924

	Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)...lb.	.05	.05½
Aluminum oxide (Al_2O_3).....lb.	.06½	.07
Antimony oxide (Sb_2O_3).....lb.	.08½	.09½
Arsenic trioxide (As_2O_3) (dense white), 99% .....lb.	.09	.09½
Barium carbonate ($BaCO_3$) (precipitated) .....ton	68.00	75.00
Barium hydrate ($Ba(OH)_2$).....lb.	.05	.05½
Bone ash .....lb.	.06	.07
Borax ($Na_2B_4O_7 10H_2O$).....lb.	.05	.05½
Borax, fused ($Na_2B_4O_7$) any mesh.lb.	.19	.20
Boric acid (B_2O_3), fused.....lb.	.35	.35
Cadmium Sulphide (CdS)—		
Red .....lb.	..	1.60
Orange .....lb.	..	1.65
Yellow .....lb.	..	1.80
Chrome Oxide (Cr_2O_3).....lb.	..	.36
Cobalt Oxide (Co_2O_3)—		
In bbls. .....lb.	..	2.10
In 10 lb. tins.....lb.	..	2.20
Copper oxide—		
Red (Cu_2O) .....lb.	..	.27
Black (CuO) .....lb.	..	.24
Black prepared .....lb.	..	.30
Cryolite (Na_3AlF_6) .....lb.	..	.09⅛
Feldspar—		
100 mesh .....ton	14.00-18.00	16.00-22.00
80 mesh .....ton	15.00	18.00
40 mesh .....ton	12.50	15.50
Ferrous oxide (FeO).....lb.	..	..
Fluorspar (CaF_2)—		
Powdered white, 95%.....ton	40.00	45.00
Hydrofluoric acid (HF) 60% (in lead carboys) .....lb.	..	.13
Kaolin (f.o.b. mine) .....ton	9.00	12.00
Lead Oxide (Pb_3O_4) (red lead)...lb.	.12	.12¼
Litharge (PbO) .....lb.	.11½	.11¾
Lime—		
Hydrated ($Ca(OH)_2$) (in 50 lb. paper sacks).....ton	12.50	..
Burnt (CaO) ground, in bulk.ton	9.00	..
Burnt, ground, in paper sacks.ton	11.00	..
Burnt, ground, in 280 lb. bbls. per bbl.	2.15	2.30
Magnesium carbonate ($MgCO_3$)...lb.	..	.08
Manganese 85% (MnO_2).....lb.	.03½	.04½
Nickel oxide (Ni_2O_3), black, for nickel content .....lb.	.32	.45
Nickel monoxide (NiO), green, for nickel content.....lb.	.30	.50
Potassium carbonate—		
Calcined (K_2CO_3) 96%.....lb.	.05	.05½
Hydrated (KOH) 85%.....lb.	.06½	.06¾
Potassium nitrate (KNO_3) (gran.).lb.	.06	.06¼
Potassium Permanganate ($KMnO_4$) .....lb.	.14	.15
Powdered blue .....lb.	..	.24-.26
Standard formula .....lb.	..	.32
Salt cake, glassmakers (Na_2SO_4), f.o.b. works .....ton	23.00-25.00	30.00
Selenium (Se) .....lb.	..	2.25
Soda ash (Na_2CO_3) dense, 58%— f. o. b. works.		
Bulk, spot.....Flat 100 lb.	1.40	..
Bulk, on contract....Flat 100 lb.	1.35	..
In 400 lb. bbls., on contract.100 lb.	1.69	2.40
In 400 lb. bags, on contract.100 lb.	1.45	2.16
Spot orders .05 per 100 lbs. higher.		
Sodium nitrate ($NaNO_3$), refined (Gran.) in bbls .....lb.	.04¼	.04½
Sodium selenite (Na_2SeO_3).....lb.	..	2.00
Sodium Fluosilicate (Na_2SiF_6)....lb.	.05¼	.05¾
Sulphur (S)—		
Flowers, 155 lb. bbl. Per 100 lb.	3.35	3.65-3.90
Flowers, in bags.....Per 100 lb.	3.00	3.30-3.55
Flour, heavy, in bbls..Per 100 lb.	2.50	2.80-3.05
Uranium oxide (UO_3), 100 lb lots.lb.	..	2.00
Zinc oxide (ZnO).....lb.	.08	.08¼

Monthly Summary of United States Foreign Commerce in Glass

Exports

Corrected to April 23, 1924.

	March 1923 Quantity	March 1923 Value	March 1924 Quantity	March 1924 Value	Nine Months Ending March 1923 Quantity	Nine Months Ending March 1923 Value	Nine Months Ending March 1924 Quantity	Nine Months Ending March 1924 Value
Glass and glass products (total).....	.....	857,391	.....	728,176	.....	6,854,324	.....	7,545,526
Plate and window glass—								
Window glass, common, box 50 sq. ft.....	2,120	12,125	1,881	8,212	23,045	131,582	38,281	170,567
Plate glass, unsilvered, sq. ft.....	148,262	58,575	165,045	44,793	1,590,236	617,969	1,209,939	480,615
Other window and plate glass, n.e.s.....lbs.	296,430	32,079	172,854	20,649	2,216,592	234,554	1,775,768	199,688
Glass containers (bottles, vials and jars).....lbs.	5,219,714	261,156	4,524,541	233,279	40,455,123	2,065,187	48,617,315	2,347,257
Table glassware, plain.....lbs.	1,648,087	166,122	1,153,033	132,568	13,447,127	1,400,860	14,151,532	1,592,842
Table and other glassware, cut or engraved....lbs.	49,299	19,662	25,751	10,222	423,463	165,040	397,761	132,674
Glass for lighting—								
Lamp chimneys and lantern globes.....lbs.	184,111	37,429	217,494	36,867	1,151,426	224,749	1,525,922	285,994
Globes and shades for lighting fixtures.....lbs.	110,876	39,561	125,887	37,931	1,170,737	332,877	1,310,349	358,499
Lamps and other illuminating devices, chiefly of glass .....lbs.	171,696	42,398	77,571	20,105	879,822	267,543	1,115,225	286,830
Chemical glassware .....lbs.	15,783	17,258	18,133	10,909	157,088	106,709	191,285	133,162
Electrical glassware, except for lighting.....lbs.	315,657	24,301	189,555	20,343	2,296,352	150,279	1,913,869	154,753
Other glassware, n.e.s.....lbs.	894,048	146,725	1,041,763	152,298	6,470,249	1,156,975	9,099,762	1,402,645

Imports

Corrected to April 23, 1924.

	March 1923 Quantity	March 1923 Value	March 1924 Quantity	March 1924 Value	Nine Months Ending March 1923 Quantity	Nine Months Ending March 1923 Value	Nine Months Ending March 1924 Quantity	Nine Months Ending March 1924 Value
Glass (total).....	.....	1,727,459	.....	1,442,389	.....	13,002,332	.....	18,659,602
Cylinder, crown, and sheet lbs.—								
Unpolished, lbs. .....dut.	4,095,393	162,916	1,735,072	93,961	35,573,089	1,462,635	26,846,442	1,350,779
Bent, ground, beveled, colored, painted, etc. and polished .....dut.	.....	78,954	.....	56,599	.....	[2]351,170	.....	564,283
Plate glass—								
Unsilvered, sq. ft.....dut.	1,954,825	1,032,470	1,469,557	953,602	13,128,134	6,608,418	19,394,288	12,451,351
Fluted, rolled, etc., or silvered, or containing wire netting, sq. ft.....dut.	155,348	17,288	153,748	16,084	[2]1,056,263	[2]192,937	1,644,527	250,669
Containers—bottles, vials, etc.....dut.	.....	53,302	.....	5,301	.....	268,680	.....	104,021
Table and kitchen utensils, lbs.....dut.	18,099	7,916	39,056	11,013	[2]472,347	[2]174,425	636,523	136,954
Glassware, cut or decorated, lbs.....dut.	191,466	86,504	215,615	97,324	.....	1,277,064	2,799,875	1,238,962
Blown glassware, n. e. s., lbs.....dut.	461,539	90,201	.....	.....	[2]2,580,735	[2]595,515	[3]3,402,894	[3]881,319
Bottles, ornaments, etc., lbs.....dut.	.....	.....	206,062	63,182	.....	.....	[4]497,985	[4]179,218
Bulbs or electric lamps, lbs.....dut.	.....	.....	972,064	17,513	.....	.....	[4]1,514,242	[4]31,473
Chimneys, globes, shades, etc., lbs.....dut.	.....	.....	269,228	47,700	.....	.....	[4]890,689	[4]144,204
Articles and utensils for chemical, scientific, and experimental purposes, lbs.....dut.	.....	.....	67,855	25,236	.....	.....	[4]182,051	[4]71,891
Other glassware..... free	.....	.....	.....	.....	[1]44,483	[1]44,253	.....	.....
dut.	.....	197,908	.....	54,874	.....	2,027,235	.....	1,254,478

[1]July to Sept. 21, 1922. [2]Beginning Sept. 22, 1922. [3]July 1 to Dec. 31, 1923. [4]Beginning Jan. 1, 1924.